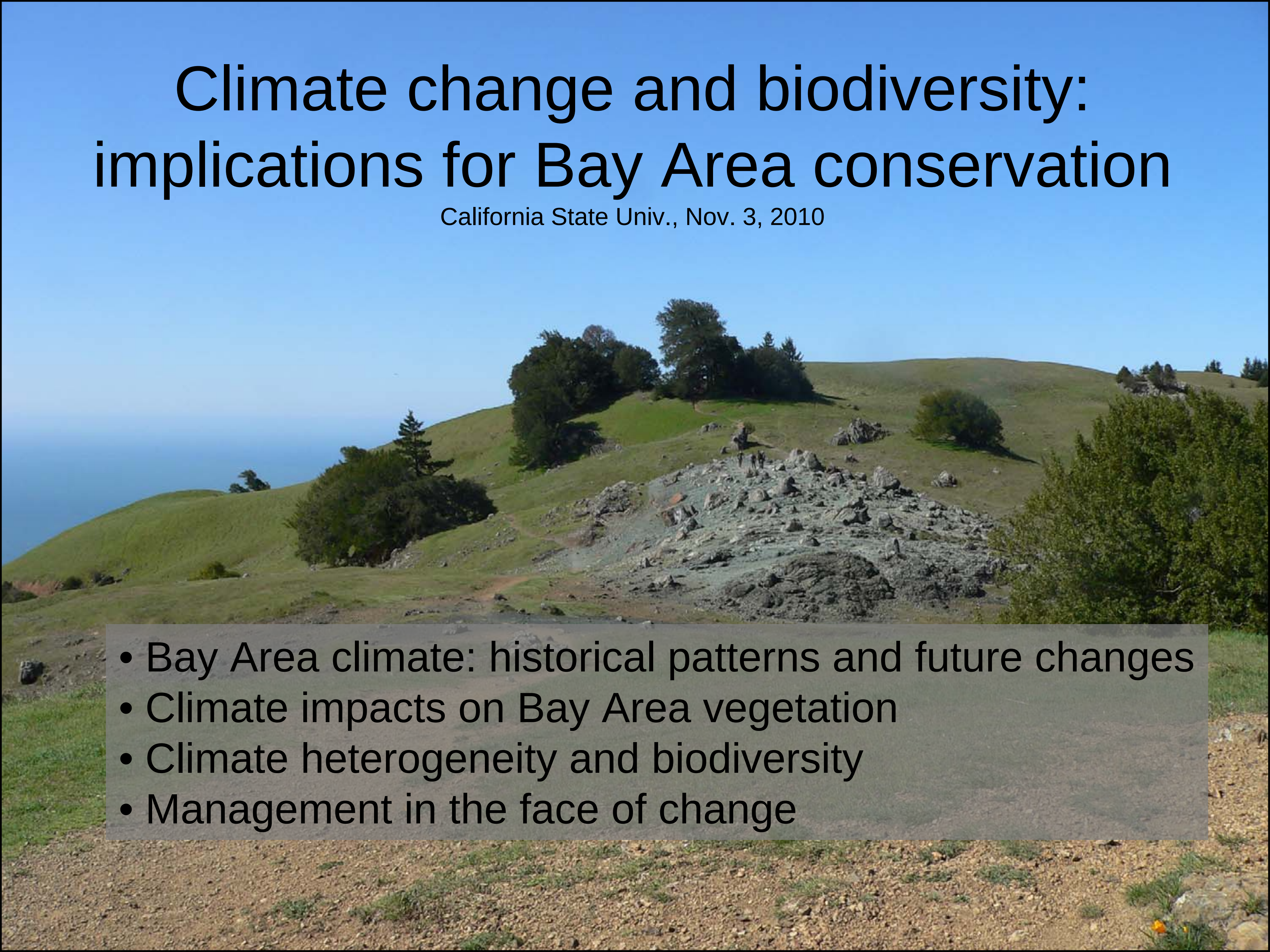
Climate change and biodiversity: implications for Bay Area conservation

California State Univ., Nov. 3, 2010



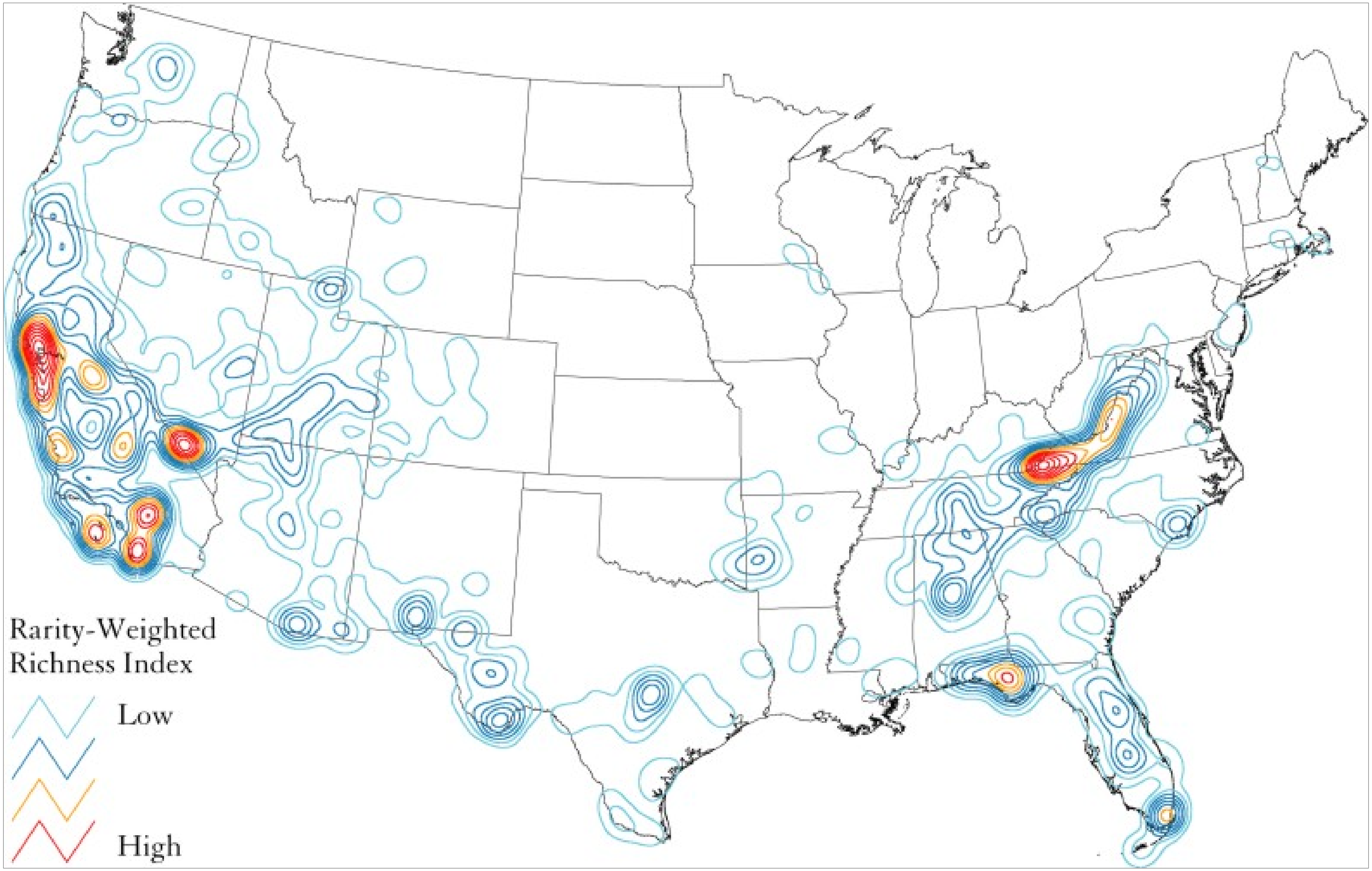
- Bay Area climate: historical patterns and future changes
- Climate impacts on Bay Area vegetation
- Climate heterogeneity and biodiversity
- Management in the face of change

Bay Area Climate Change and Protected Areas Workshop
'The Pepperwood Meeting'
July 19-21, 2010

Left to right: Miguel Fernandez, Jim Thorne, Mary Lee Hannah, Alicia Torregrosa, Stu Weiss, Mike Hamilton, Meg Krawchuk, Will Cornwell, Nicole Heller, Al Flint, David Ackerly, Lorrie Flint, Ryan Branciforte, Scott Loarie, Dave Conklin, Jason Kreitler, Sam Veloz, Lisa Micheli, Healy Hamilton, Max Moritz, Morgan Kennedy, Beth Sabo, Jim Johnstone

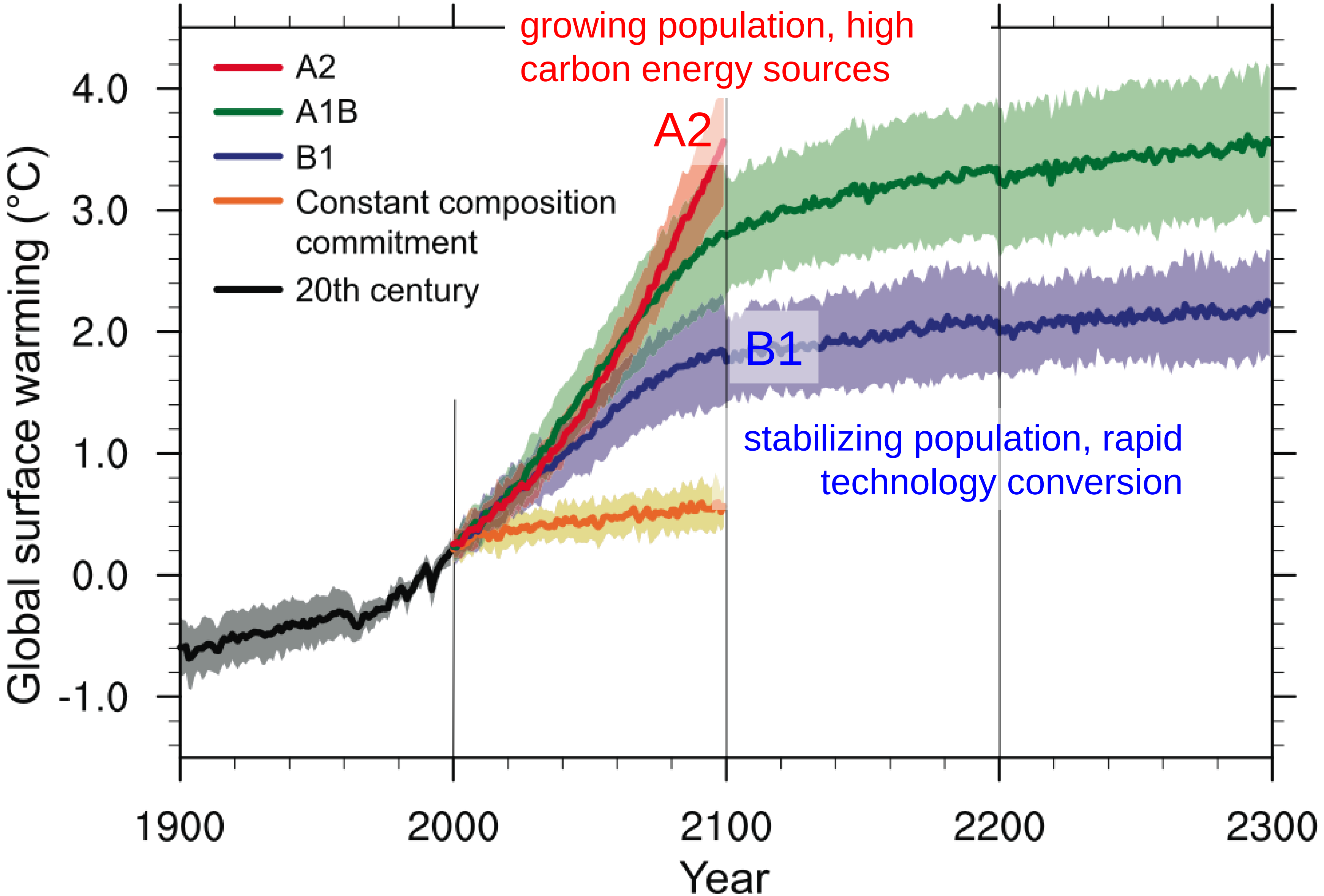
Missing: Kirk Klausmeyer, Lee Hannah, Diana Stralberg, Phil Duffy, Karen Gaffney, Adina Merenlender

Biodiversity hotspots in the United States



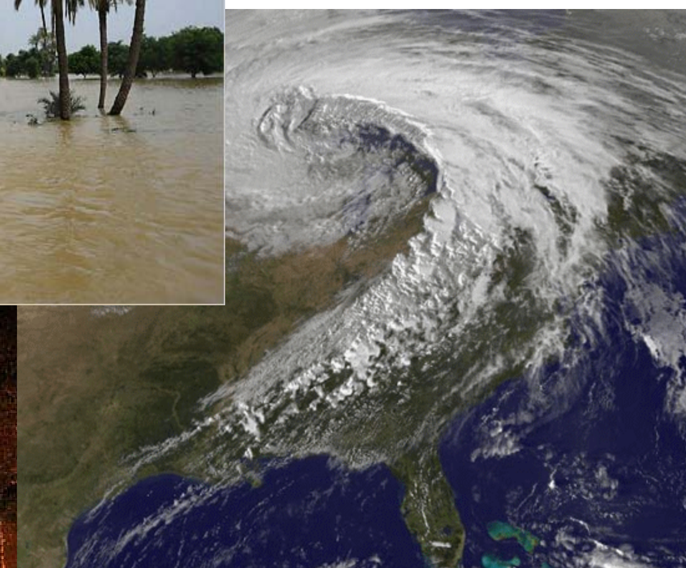
from *Precious Heritage*, 2000, Nature Conservancy and NatureSe

Projections of future temperature – IPCC 4th assessment



IPCC 2007, Fig. 10.4

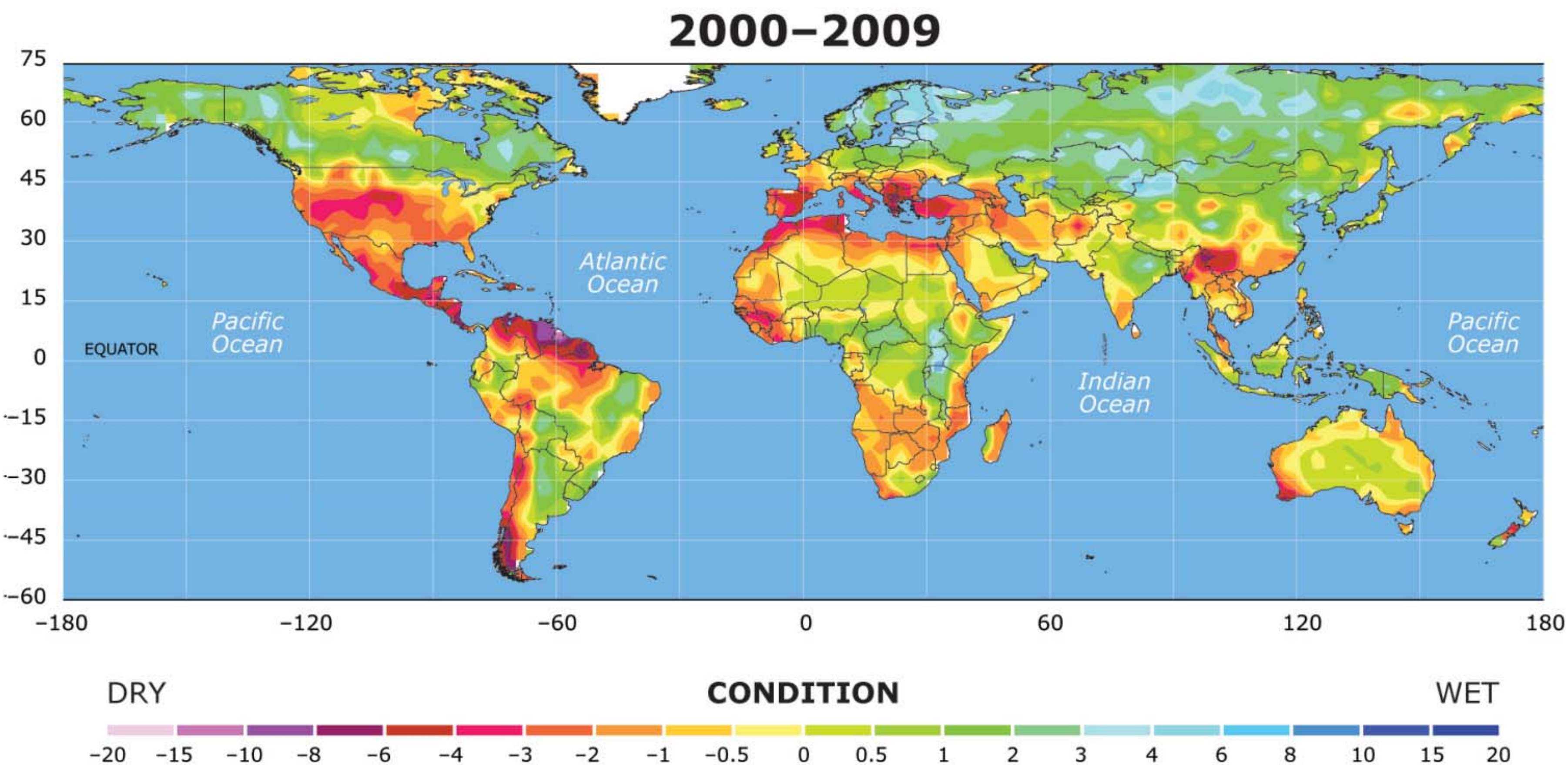
↑ Extreme, Unpredictable, Deadly Weather Events



US Climate Change Science Program
www.globalchange.gov

Record-breaking flooding Pakistan; heat/fire in Russia; ‘mud slides in China NY Times, August 15, 2010;
Superstorm over midwest-- lowest barometric pressure recorded in continental US, October 26, 2010

Extreme Drought Globally & Permanent Dust Bowls in US West over Decades Ahead

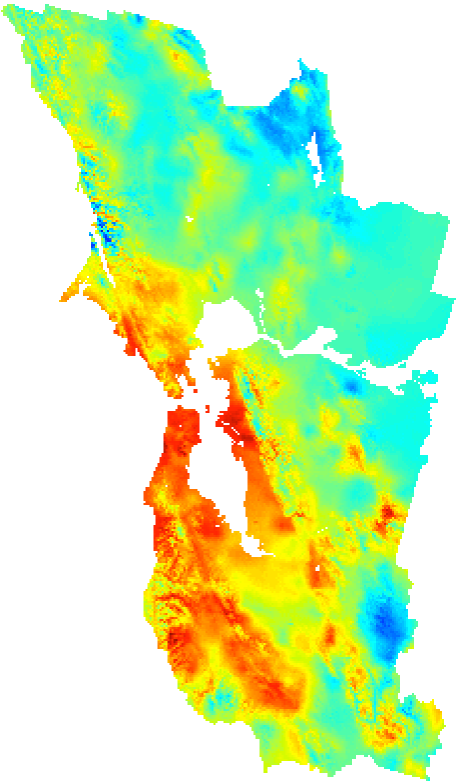


Palmer Drought Severity Index of -4 or lower considered extreme drought; UCAR graphics; not forecasts

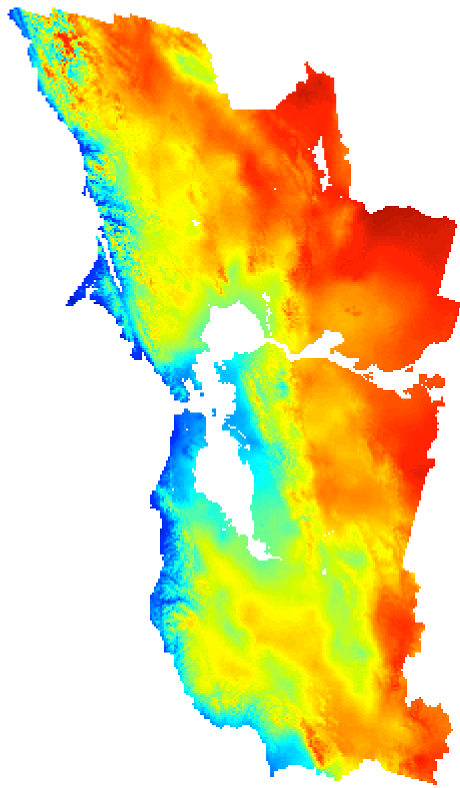
Drought under global warming: a review, Aiguo Dai , National Center for Atmospheric Research, 19 Oct 2010

http://onlinelibrary.wiley.com/doi/10.1002/wcc.81/full

Bay Area climate

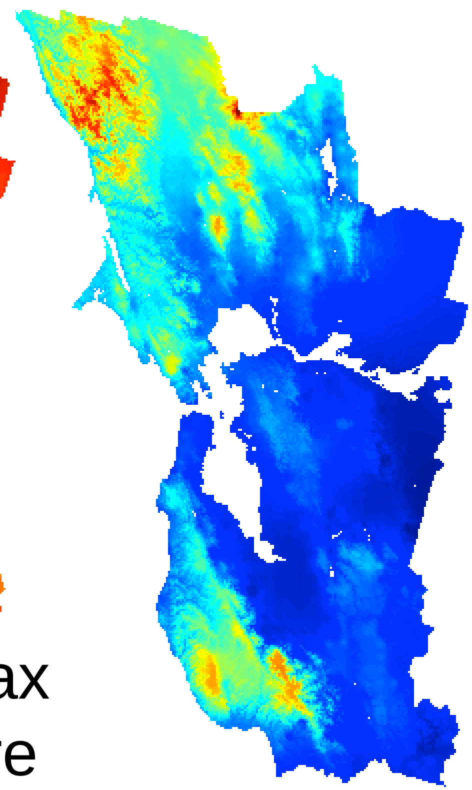


winter min temperature

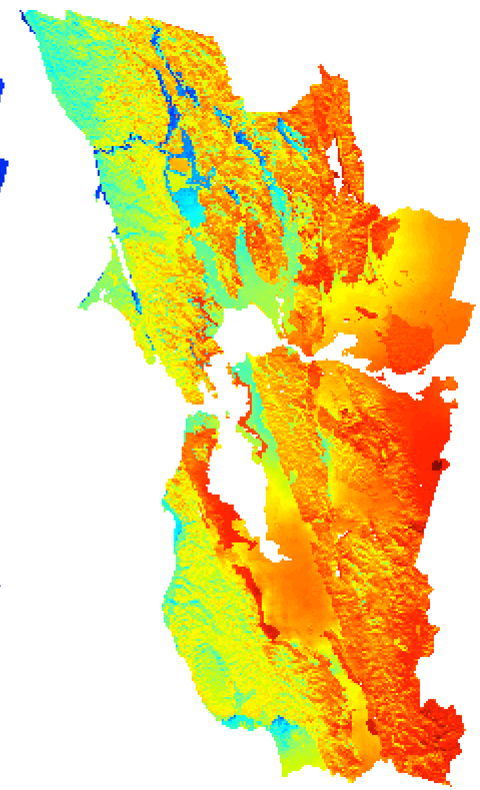


summer max temperature

precipitation

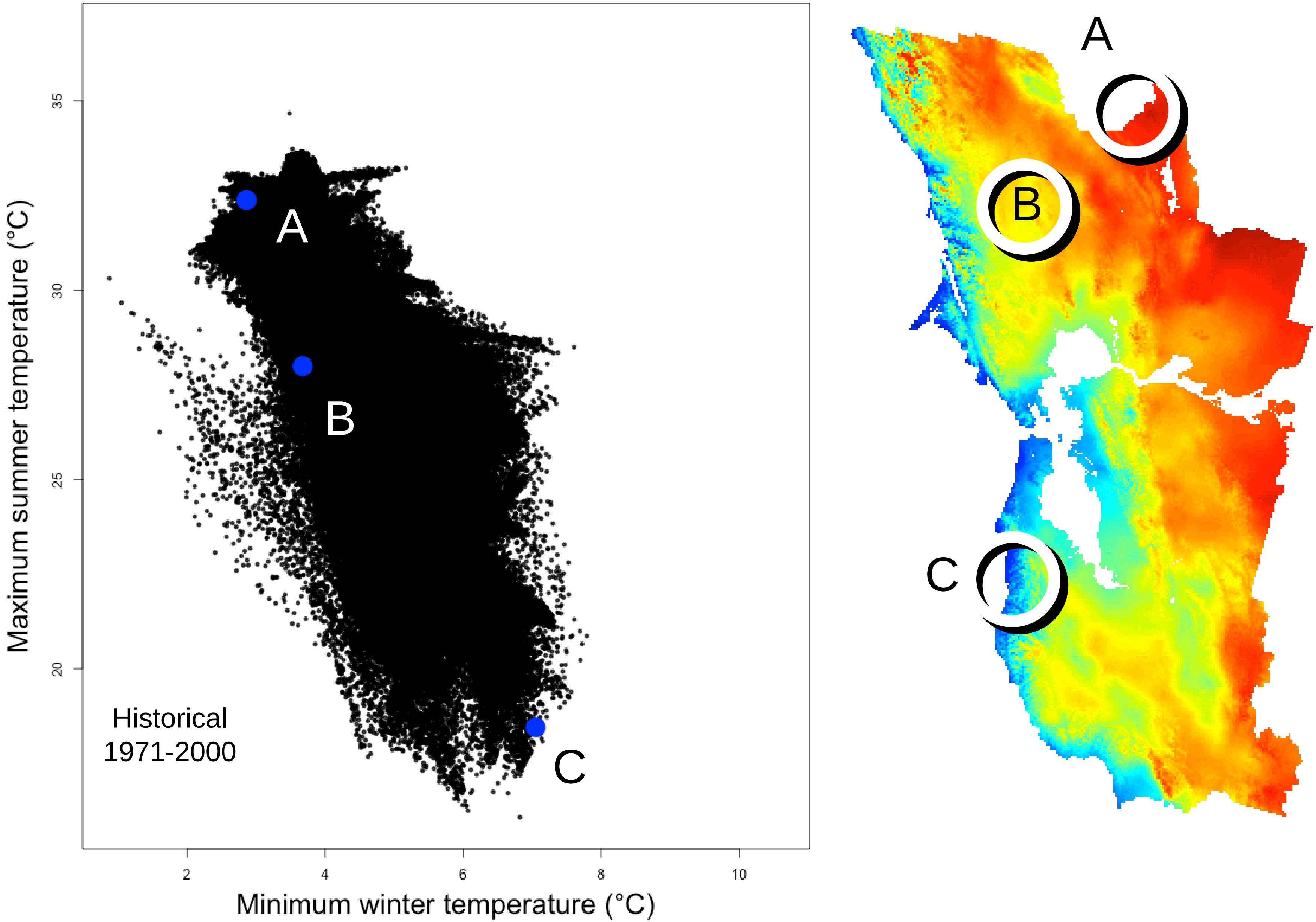


water deficit

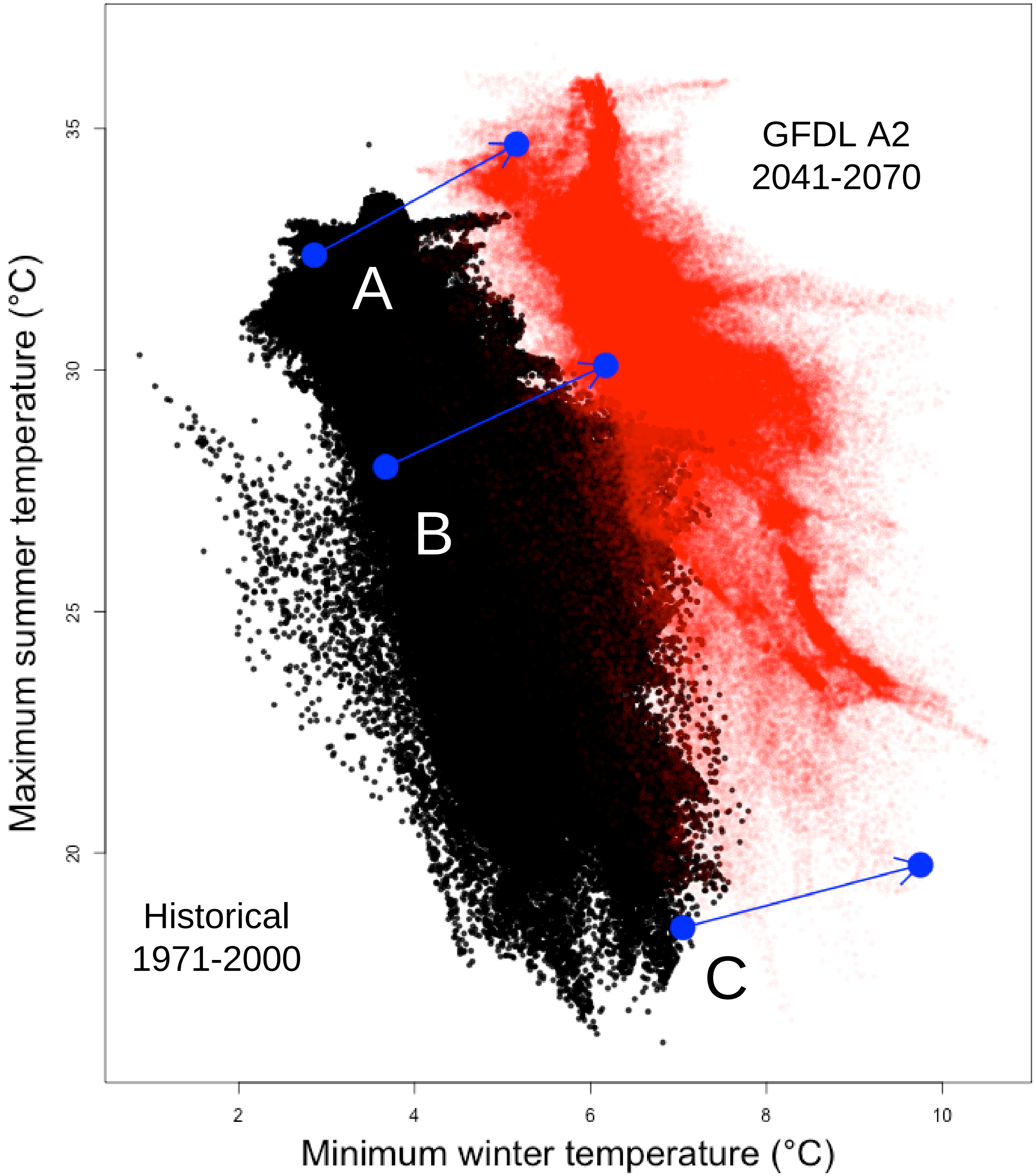


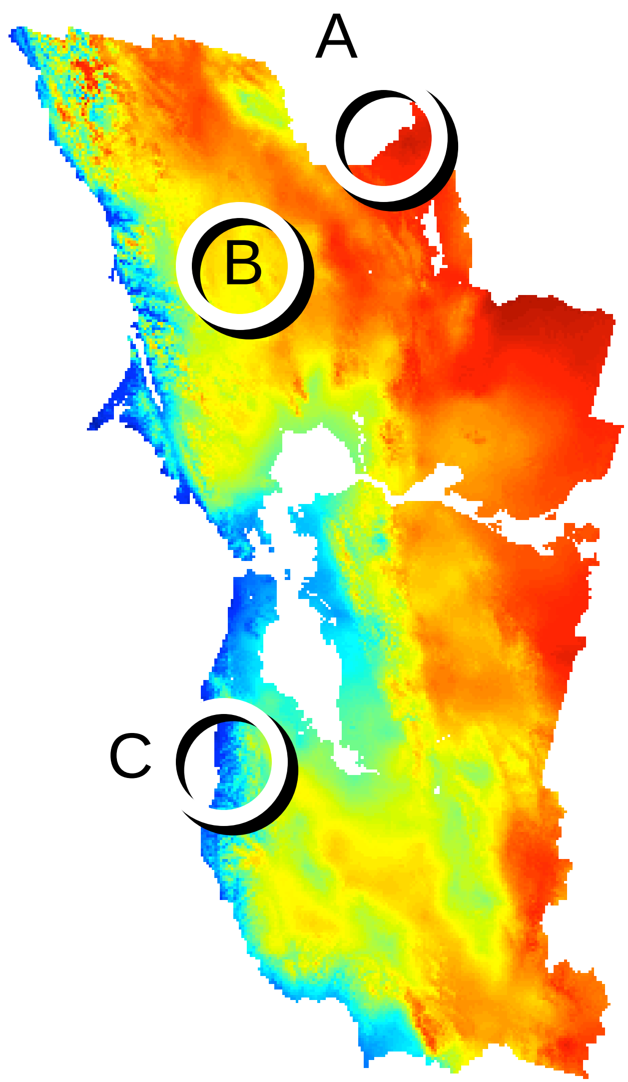
PRISM climate layers downscaled to 270 m by Al and Lorrie Flint, USGS

Summer and winter temperatures are negatively correlated across the Bay Area

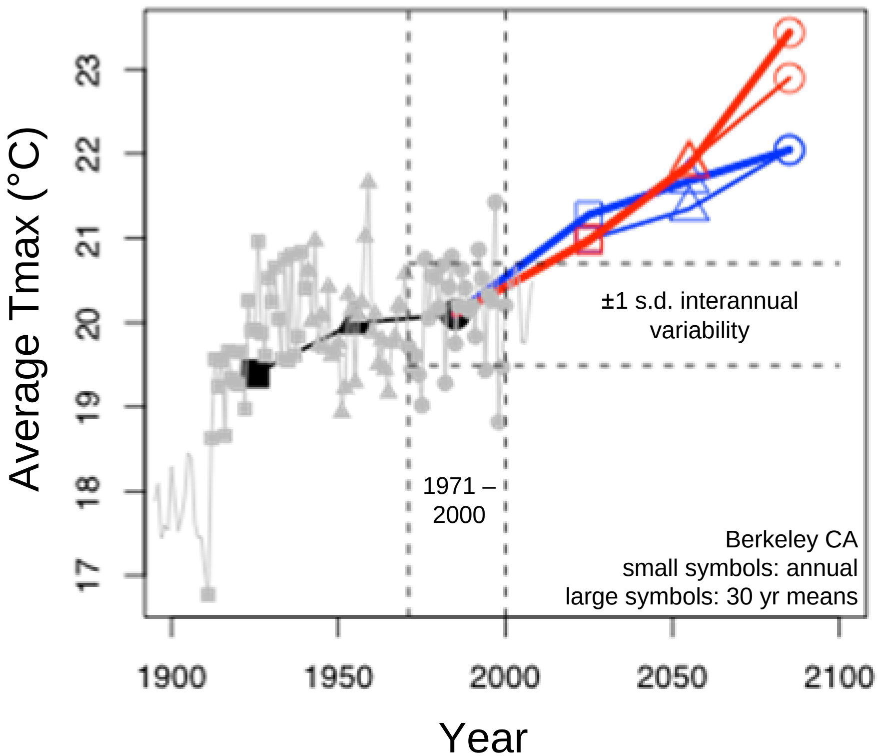


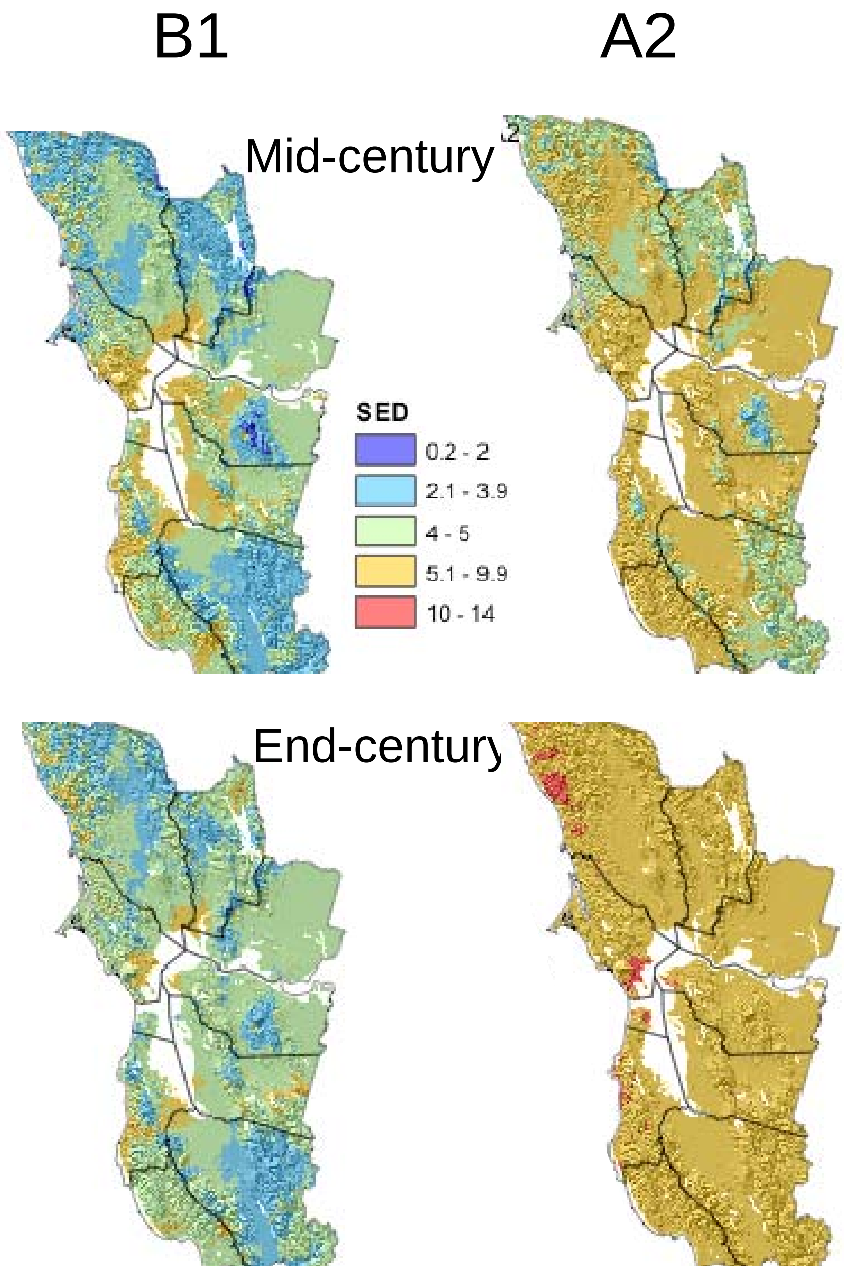
Due to the coastal-inland pattern, rising temperatures create novel climates throughout the Bay Area





Future climates will rapidly exceed the range of recent historical variability

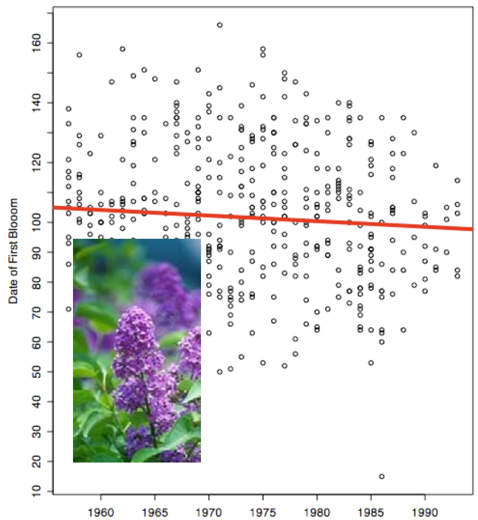




analysis and figure: Sam Veloz, PRBO

Impacts on biodiversity:
observation, experiments, models

Earlier onset of spring
(Schwarz and Caprio 2003)



Elevational shifts in plants and small mammals
(Kelly and Goulden 2008, Moritz et al. 2008)

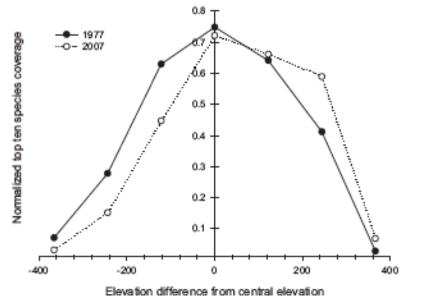
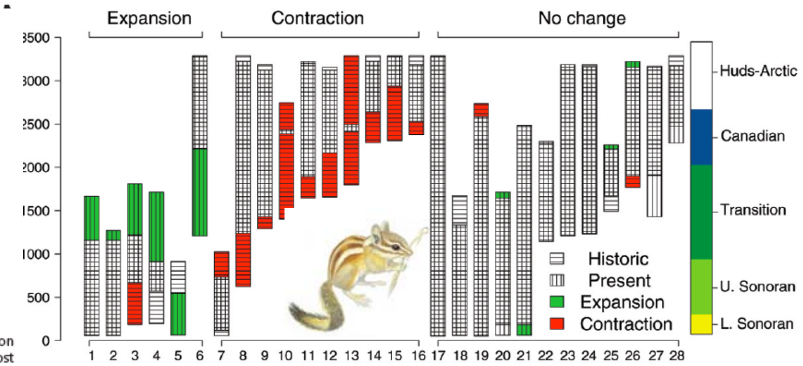
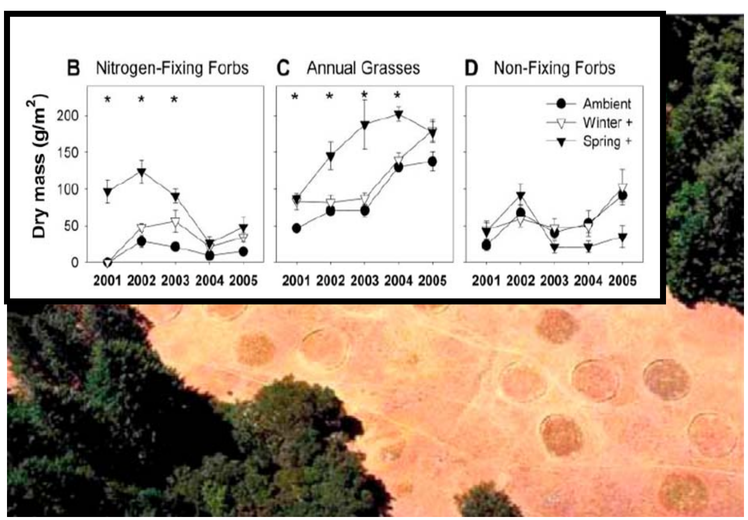


Fig. 3. Changing vegetation distribution from 1977 to 2006–2007. Elevation distribution of the mean normalized vegetation coverage of the ten most widely distributed species in 1977 and 2006–2007.



Global change experiments in grasslands
(Suttle et al. 2007, Shaw et al. 2002)



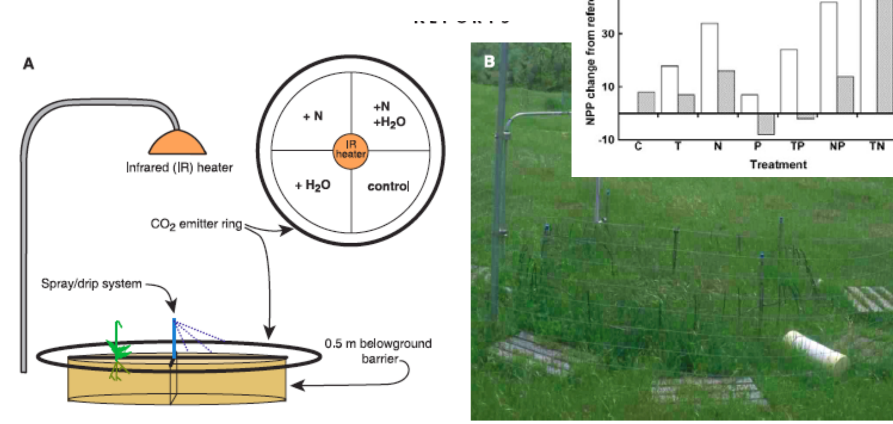
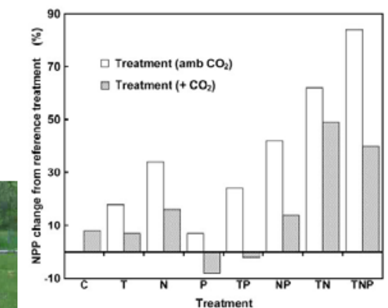
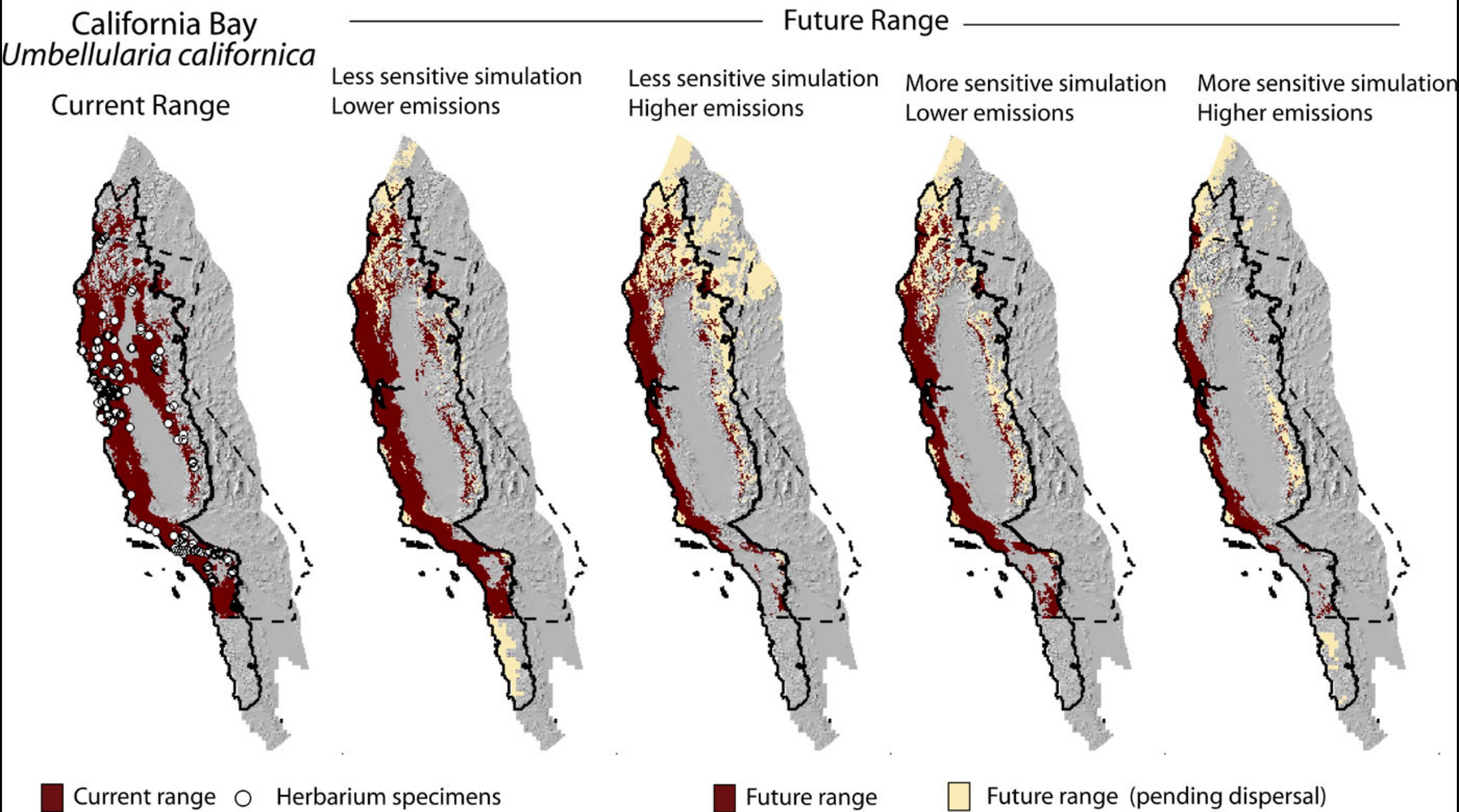


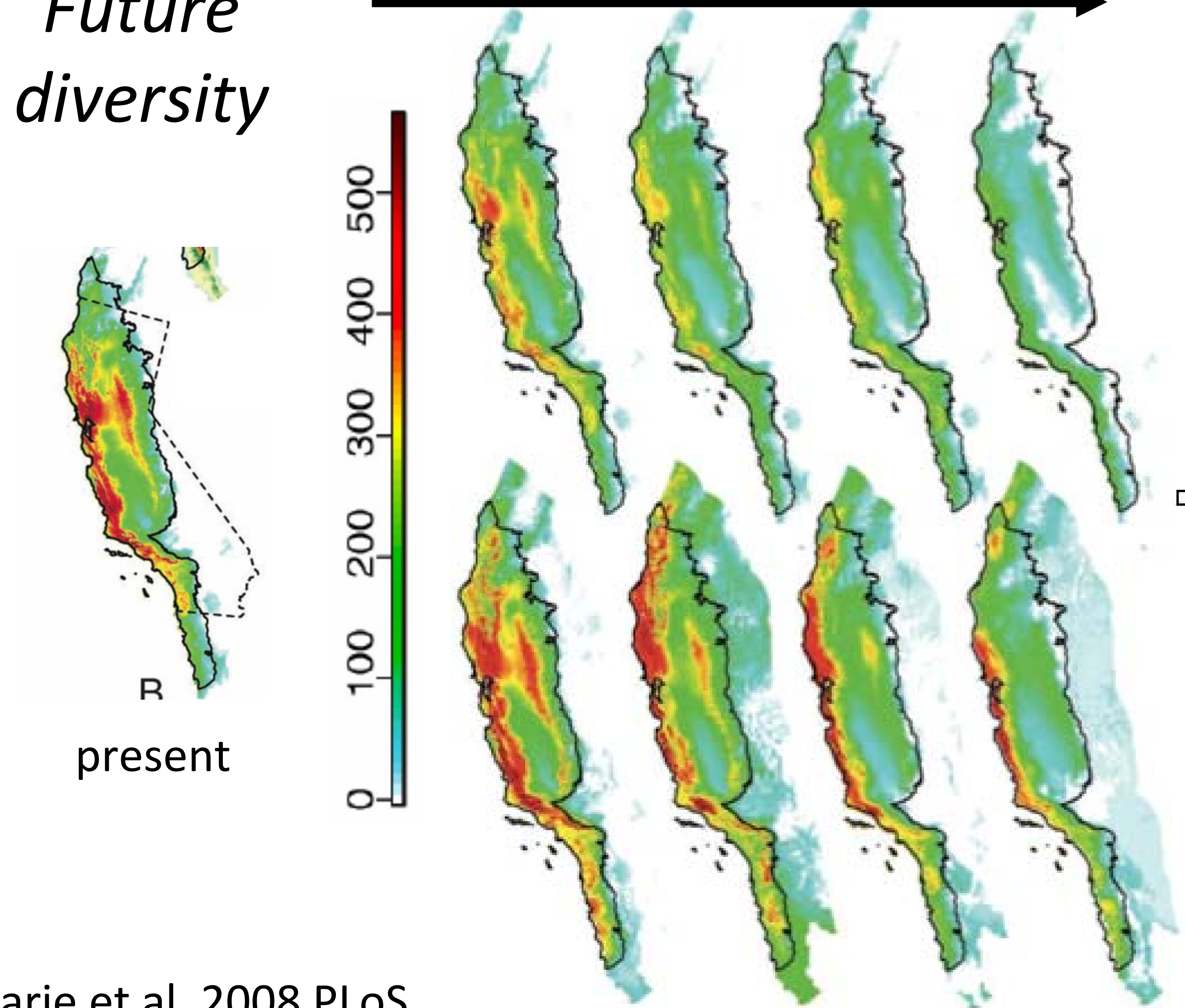
Fig. 1. (A) Schematic drawing of the study plots, side view (left) and top view (right). The plot is 2 m in diameter. (B) Photograph of a study plot.




California Bay
Umbellularia californica
Current Range
Future Range
Less sensitive simulation
Lower emissions
Less sensitive simulation
Higher emissions
More sensitive simulation
Lower emissions
More sensitive simulation
Higher emissions
Current range
Herbarium specimens
Future range
Future range (pending dispersal)

Future diversity

increasing severity of climate change



present

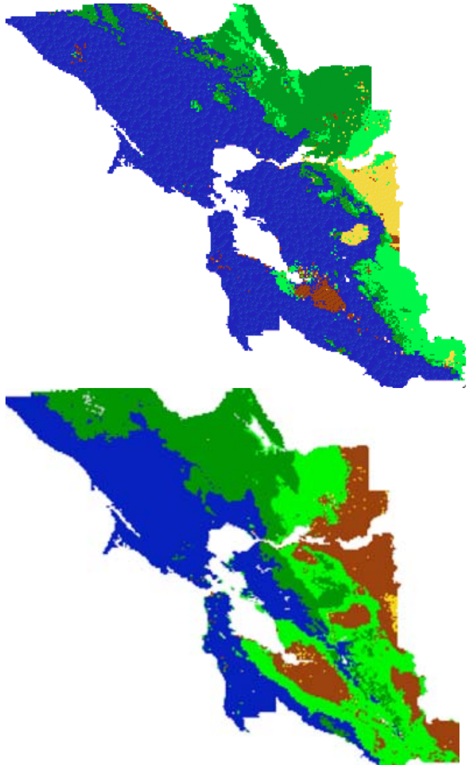
no dispersal

unlimited dispersal

Loarie et al. 2008 PLoS

Several, independent approaches to vegetation modeling agree: future climates favor shrub and grassland at the expense of forest

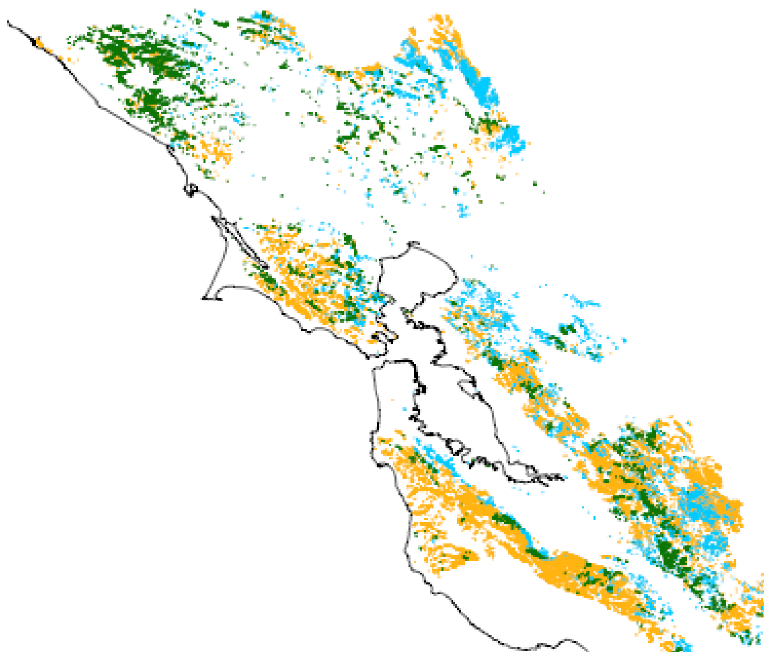
MC1 vegetation model



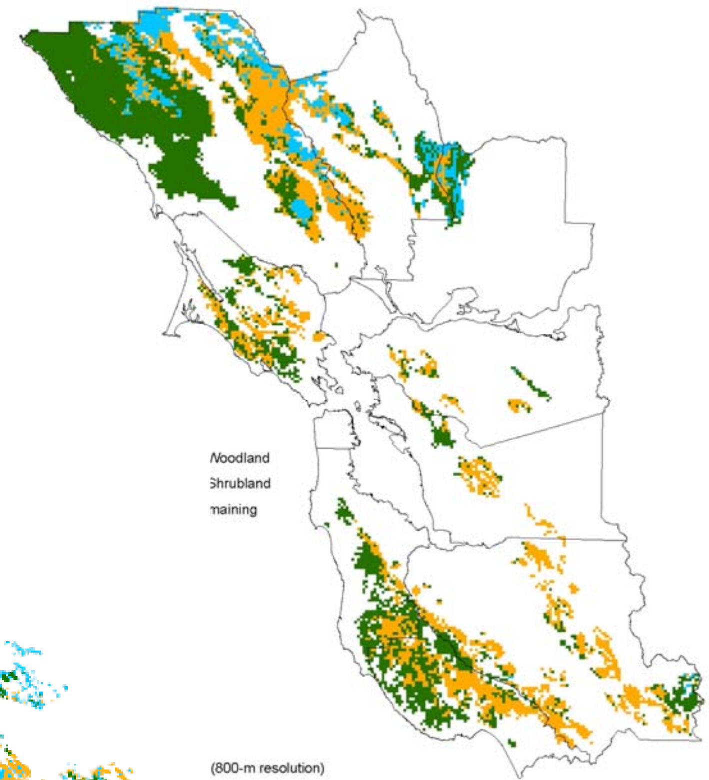
- conifer
- hardwood forest
- hardwood woodland
- grassland
- shrubland

- forest remaining
- forest → woodland
- forest → shrubland

Bay Area Vegetation Modeling (Cornwell et al. unpublished)



CalVeg distribution modeling (Stralberg et al. 2009)



Analysis and figures: Dave Conklin, Conservation Biology Institute; Diana Stralberg PRBO; Will Cornwell, UC Berkeley

Modeling Bay Area Vegetation

Desired features:

1) small grain model with a realistic representation of topography (30 m)

2) simultaneous model of all vegetation types

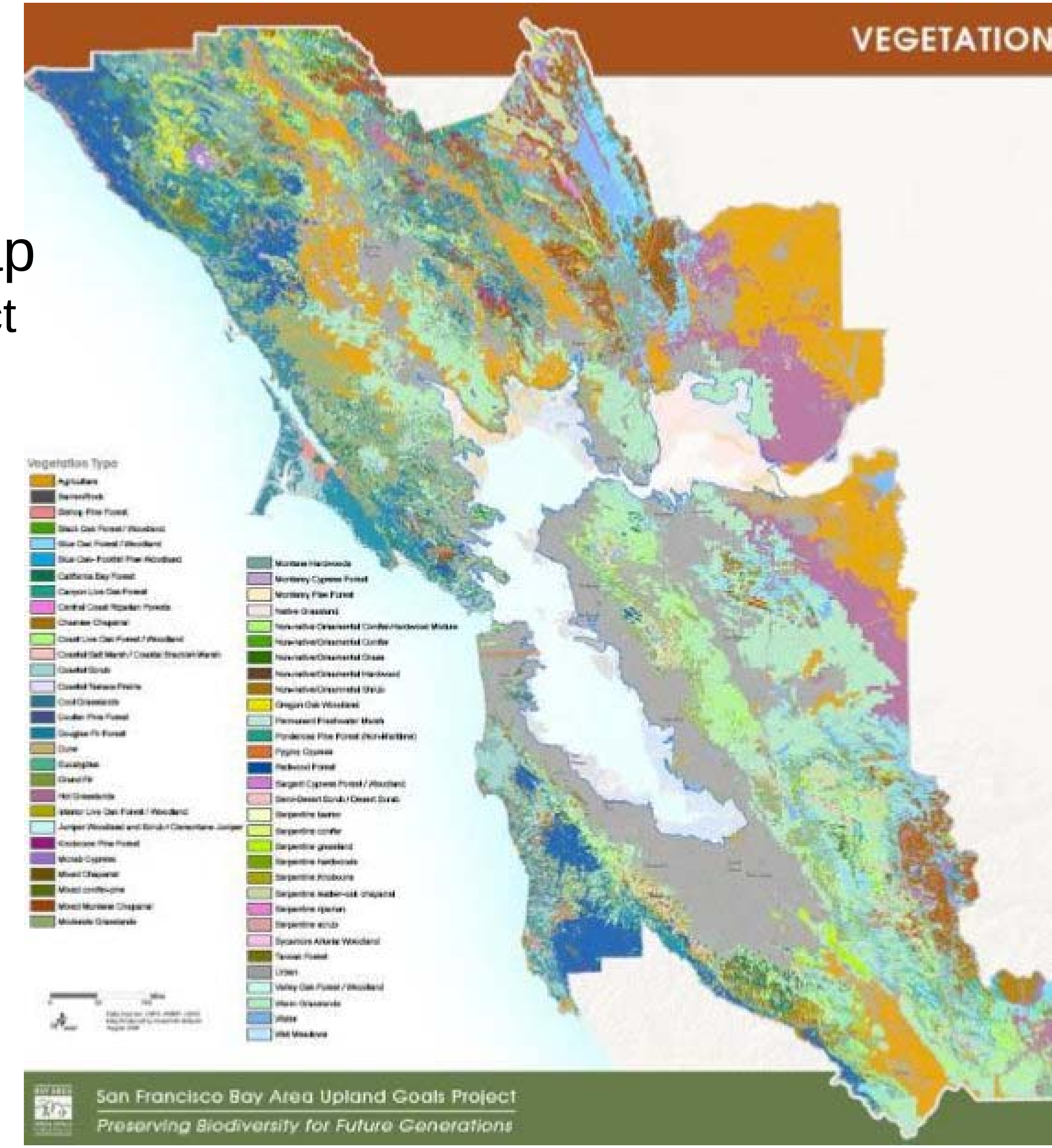
3) comparison with documented vegetation transitions

Bay Area Vegetation Map
Upland Habitat Goals Project

60 cover types
51 natural/semi-natural

30 m mapping units

Remote imagery +
vegetation plots +
expert opinion



source: Bay Area Open Space Council, Ryan Branciforte & Stu Weiss

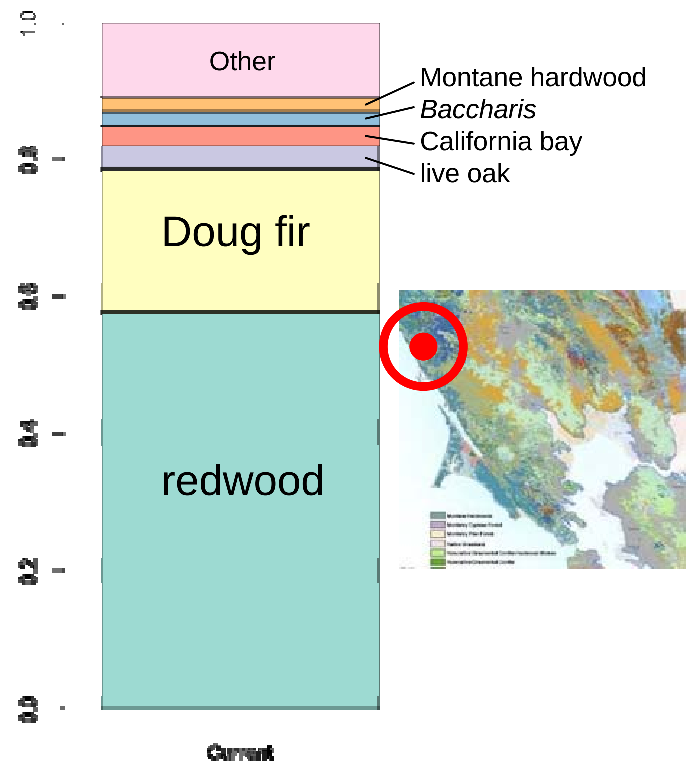
Modeling Bay Area Vegetation

Predictive layers

1) *Climatic water deficit (270 m) Al and Lorrie Flint (USGS)*
2) Potential annual insolation (annual, 30 m)
3) *Min Temp (270 m downscaled from PRISM)*
4) *Max Temp (270 m downscaled from PRISM)*
5) Wind (100 m)
6) Soil Depth (STATSGO)

multinomial logistic regression

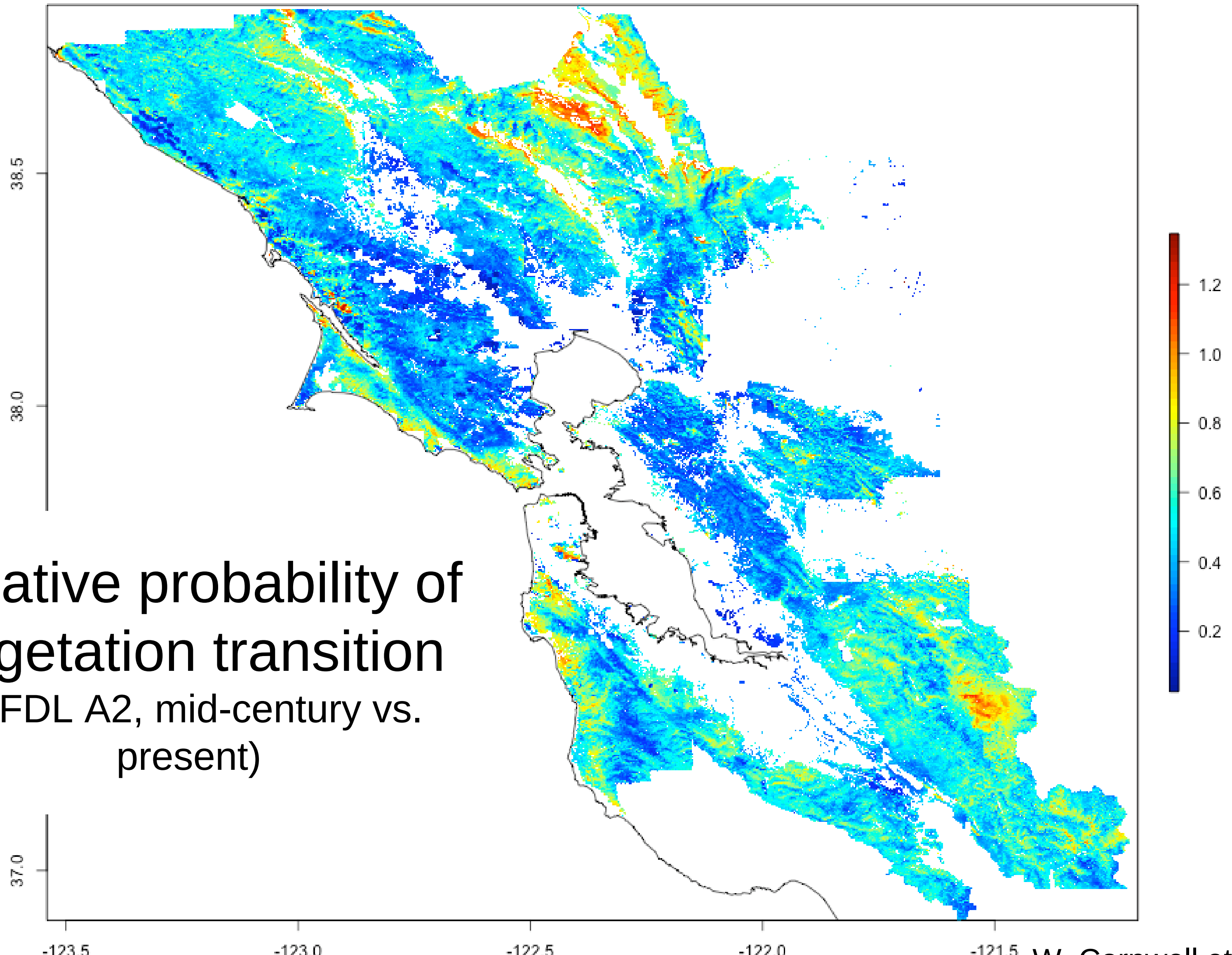
Vector of probabilities for each veg type in each pixel



W. Cornwell et al. in prep.

The vulnerability of vegetation types is very patchy:

high probabilities of change occur where vegetation patches are near the edge of their climate envelope

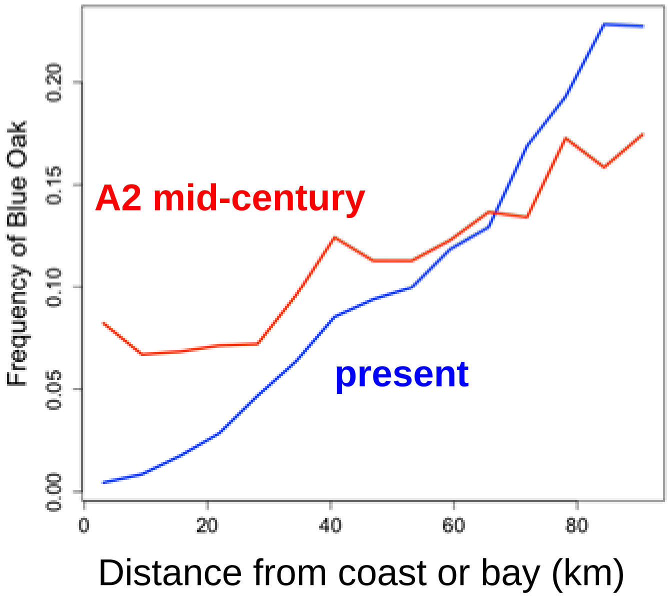


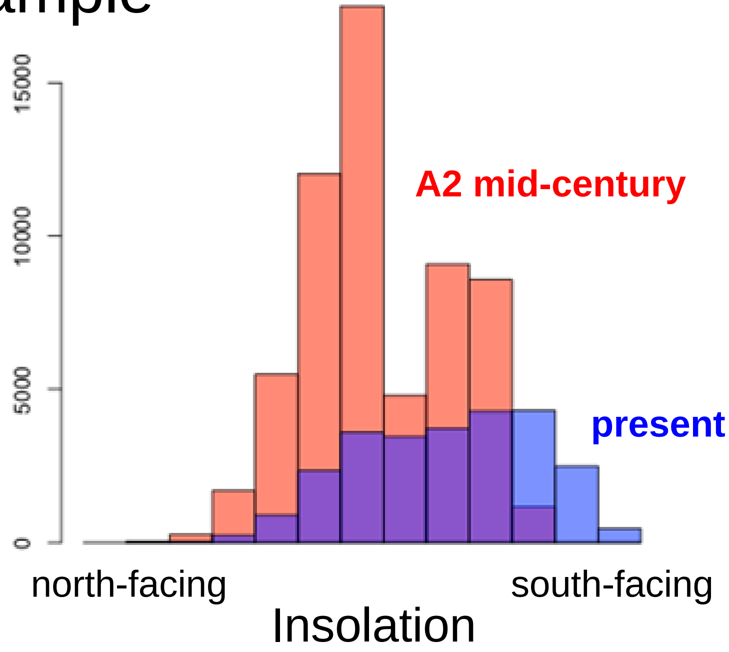
Relative probability of vegetation transition

(GFDL A2, mid-century vs. present)

W. Cornwell et al. in prep.

Regional and topographic shifts in vegetation types
Blue oak example





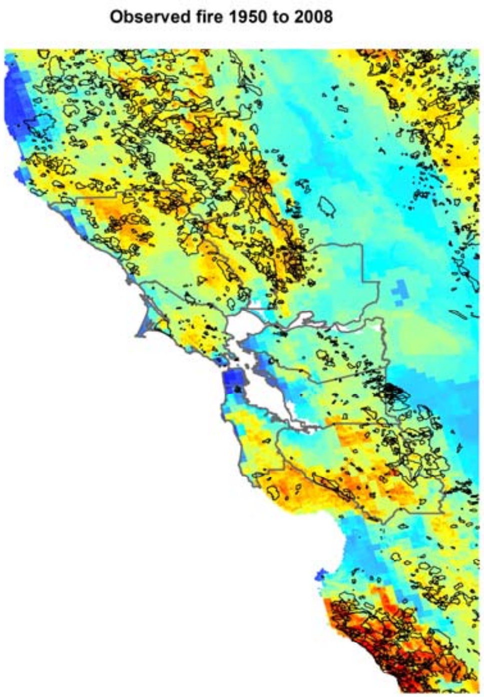
Native vegetation transitions vs. alien invasions

vegetation transitions depend on:
1)mortality of existing mature plants
2)propagule sources for new species

?

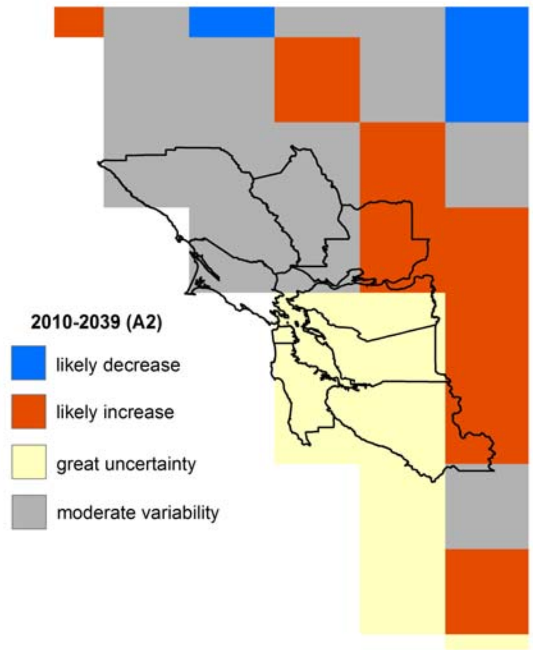
Agents of mortality: Fire

Historical probability of fire
1950-2003

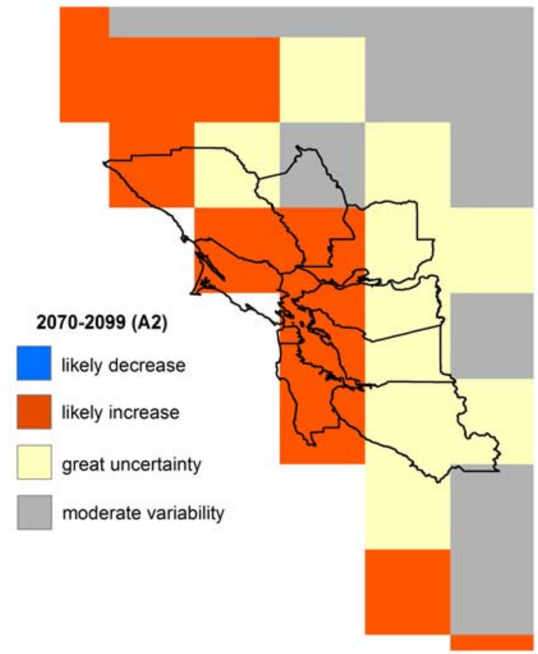


16 GCM ensemble (A2 scenario):
change relative to historical period

2010-2039 (A2)



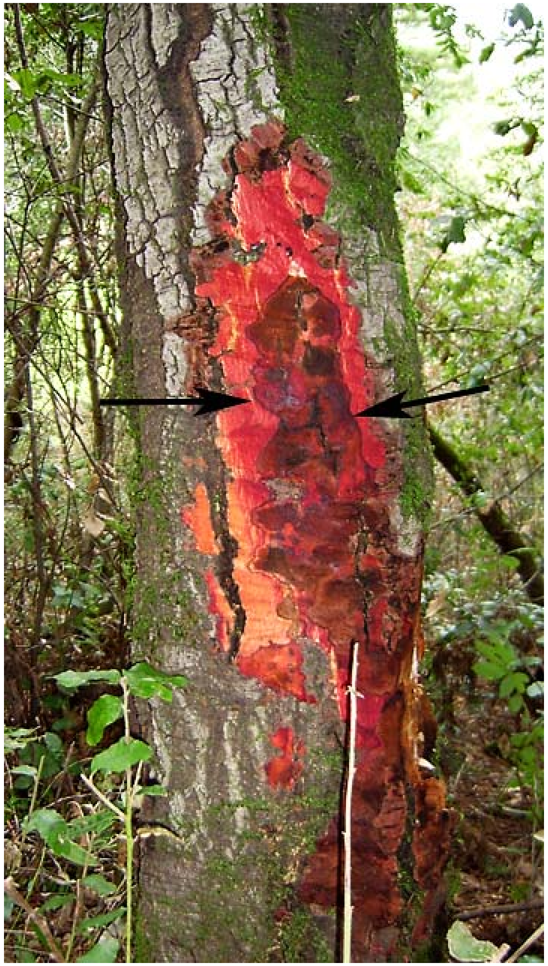
2070-2099 (A2)



Figures: courtesy Meg Krawchuck and Max Mortiz, UC Berkeley
Historical: Parisien and Moritz 2009 Ecol. Monogr.
Futures: Moritz et al. in review

Agents of mortality: Disease

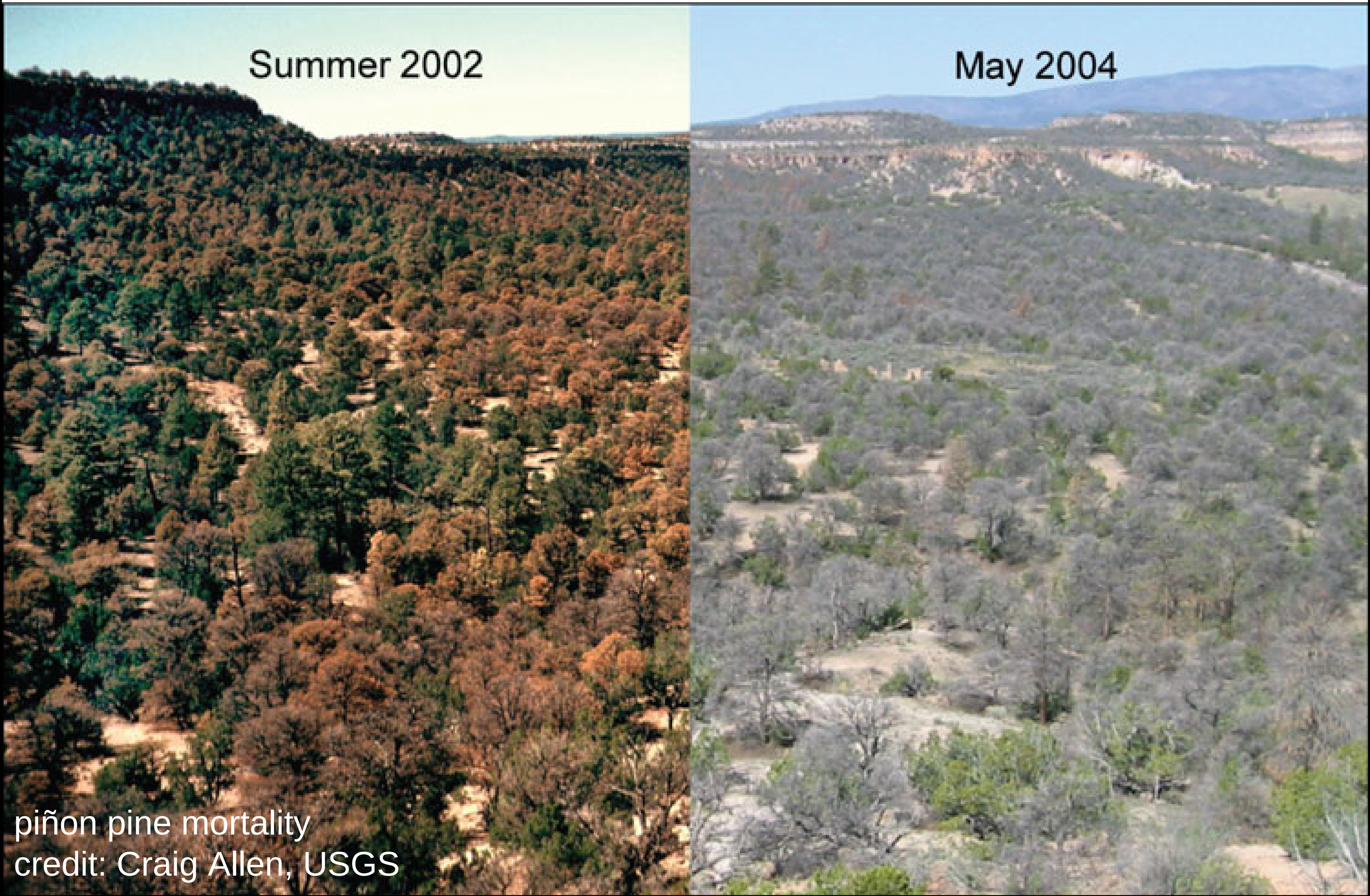
Sudden oak death



source: Center for Invasive Species Research
UC Riverside

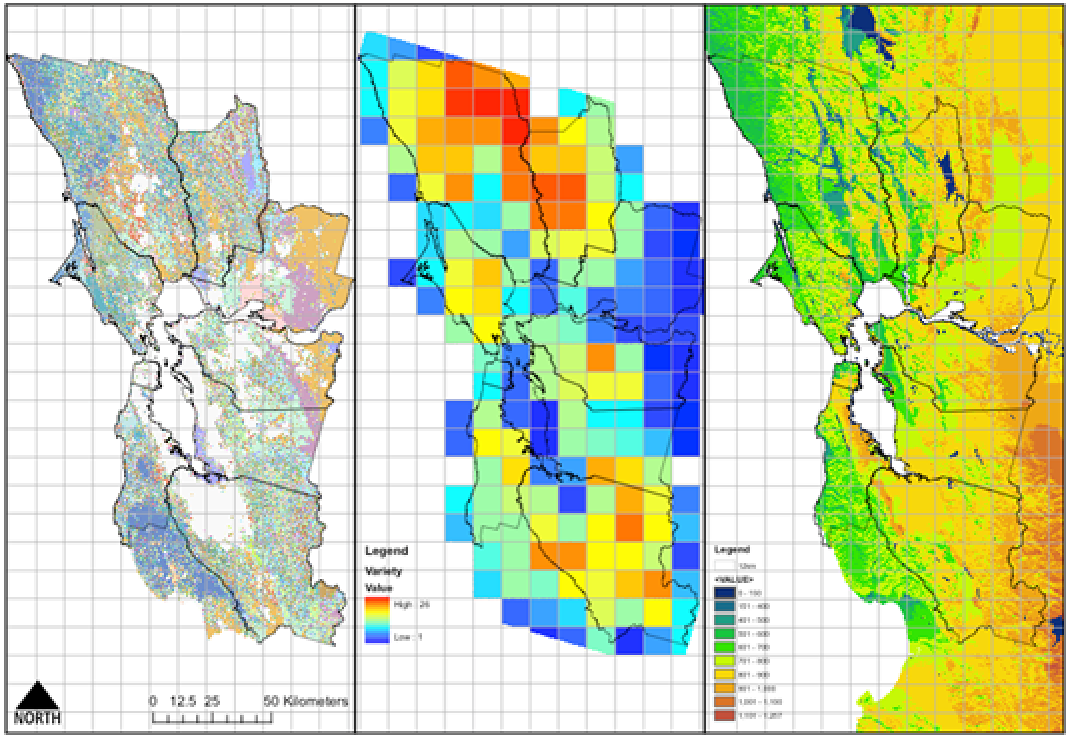
source: UC Davis; http://www.sciencedaily.com/releases/2007/08/070815145316.htm

Agents of mortality: Drought and pests



Local diversity provides seed sources for vegetation shifts

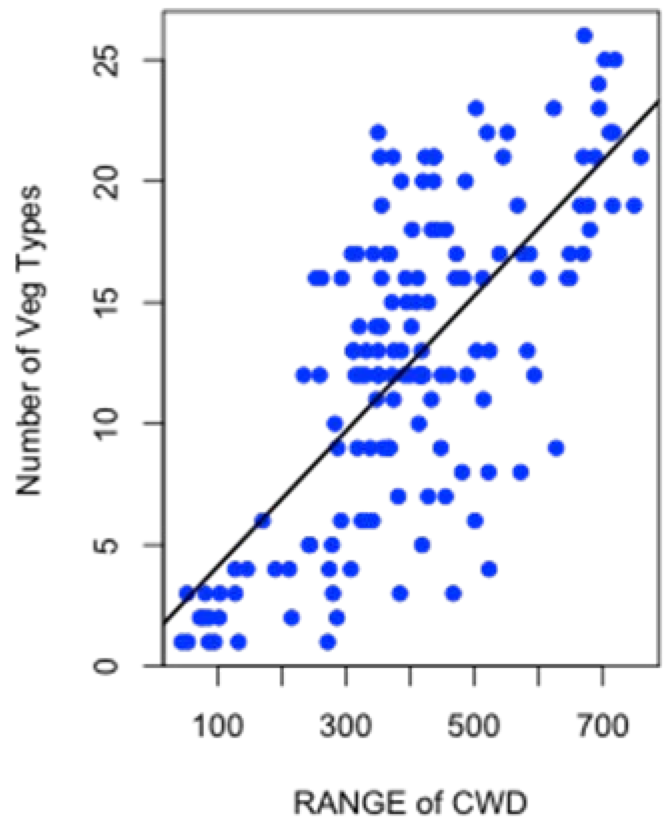
Heterogeneous landscapes support a greater diversity of vegetation types



Veg map

veg types per 12km cell

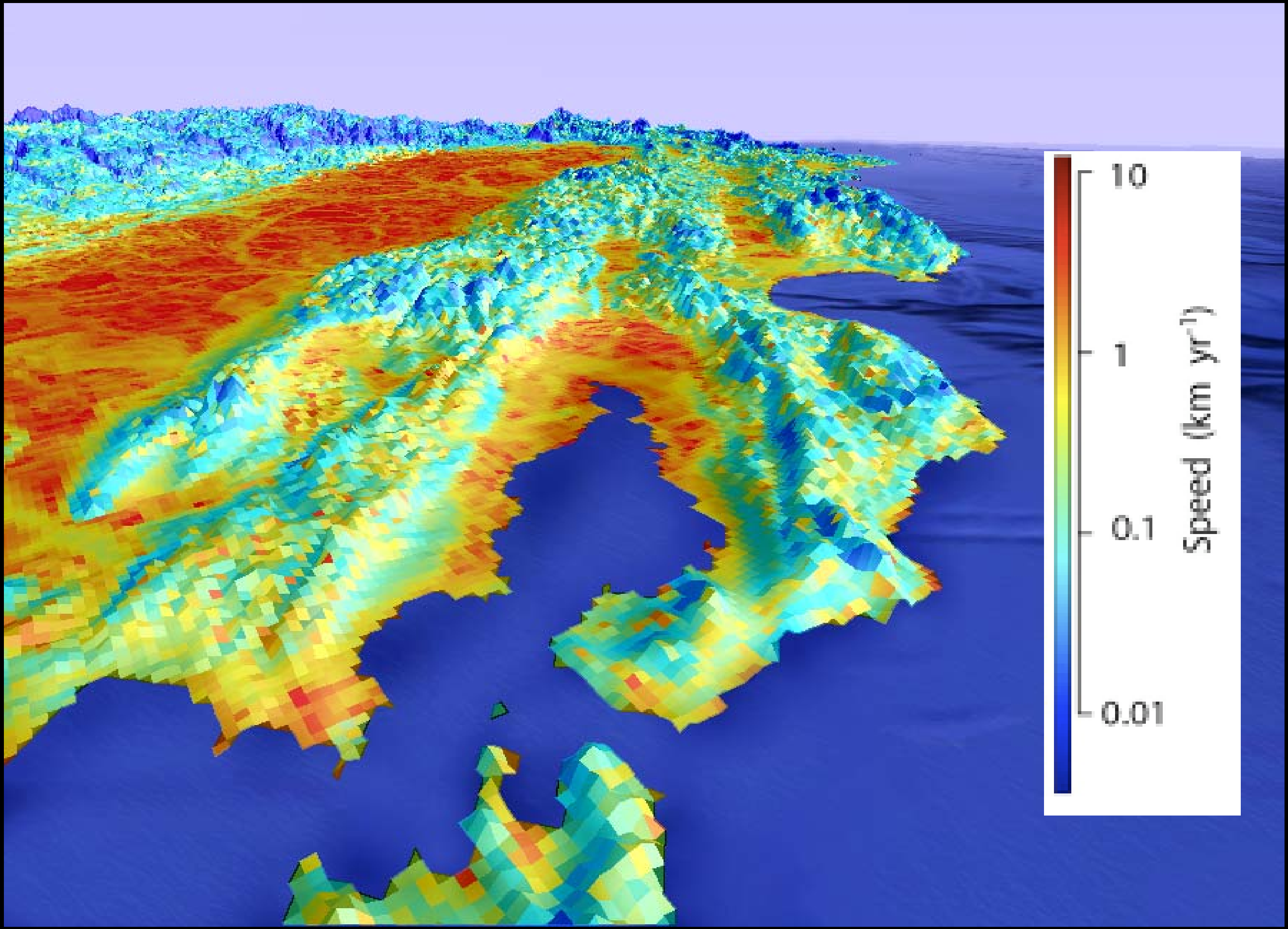
CWD



analysis and figures: Jason Kreitler, USGS and Nicole Heller, Climate Central

Velocity of climate change:

how fast will populations need to move to offset rising temperature?



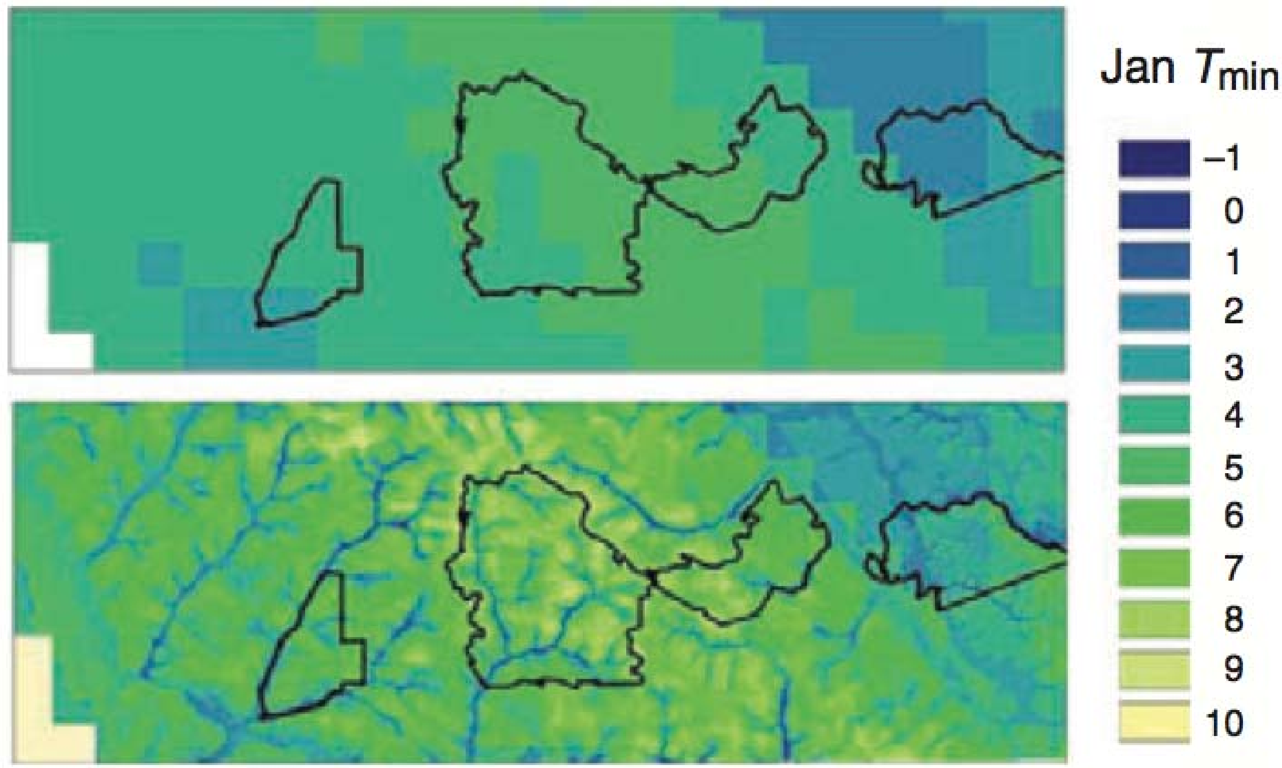
rate of climate change (°C/yr) ÷ spatial climate gradient (°C/km) = velocity (km/yr)

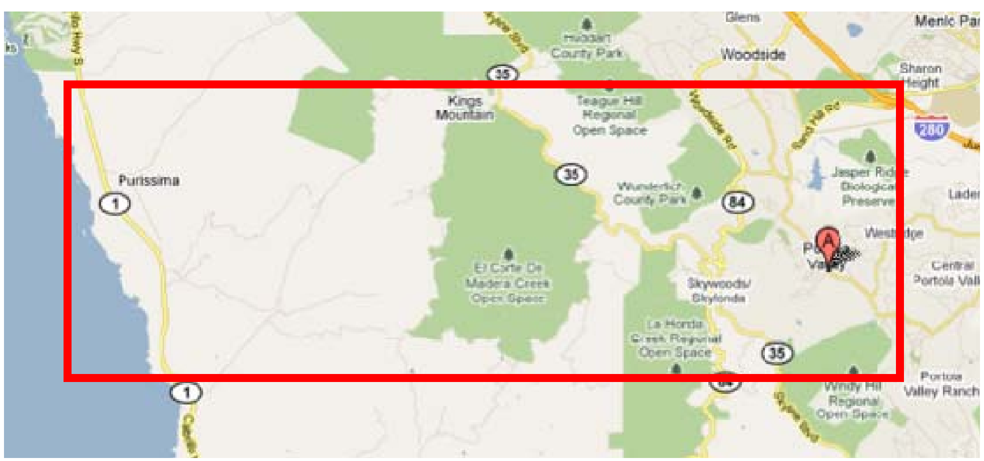
Loarie et al. 2009 Nature

Topoclimate enhances local climatic heterogeneity

PRISM 800m climate surface

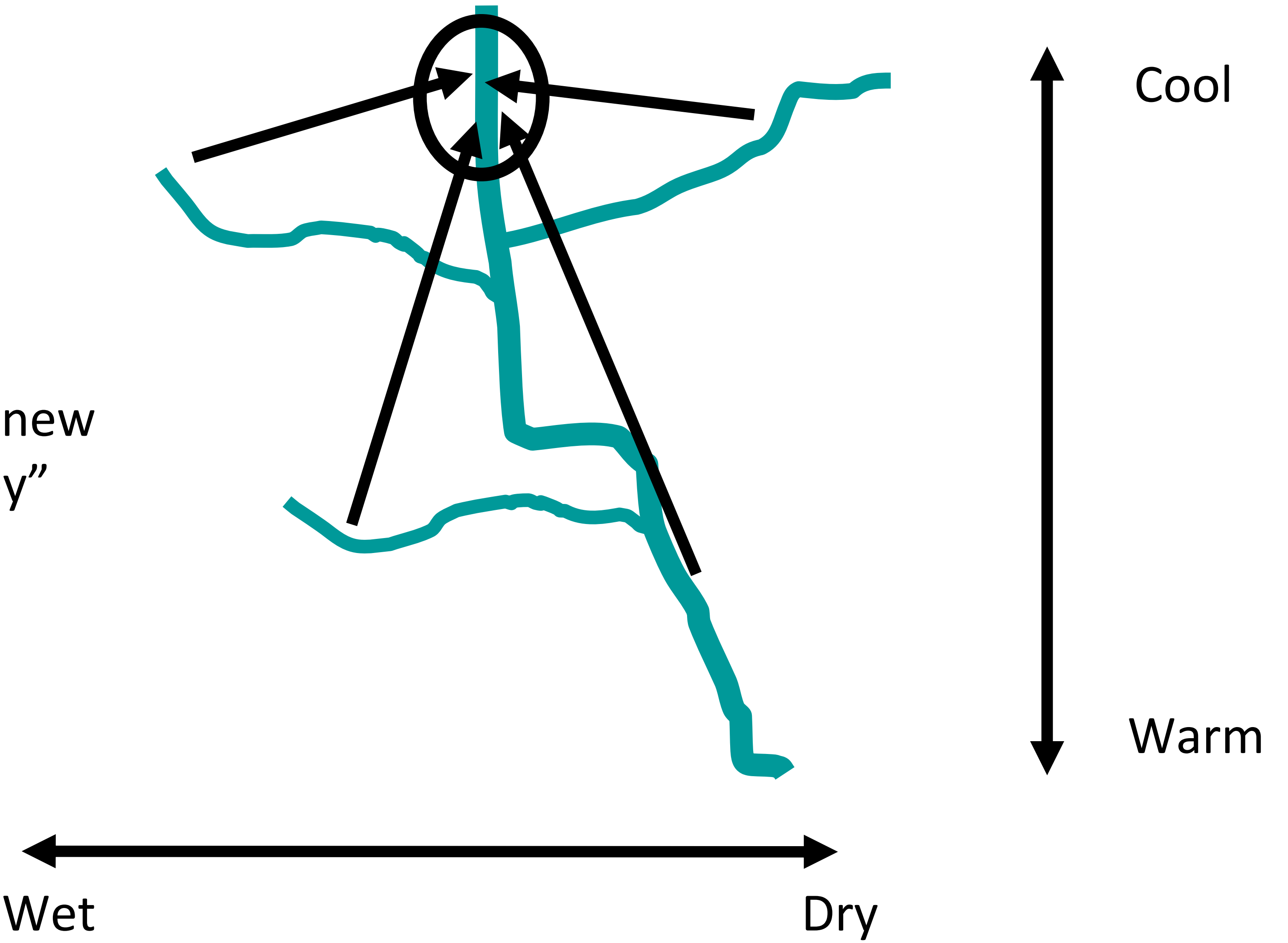
Downscaled 30m surface showing effects of cold air drainages





analysis and figures: Stu Weiss
Creekside Center for Earth Observation
Ackerly et al. 2010 Diversity and Distributions

Consider planting "new but nearby" species



Source: www.prbo.org , Seavy et al., Ecol. Rest v27

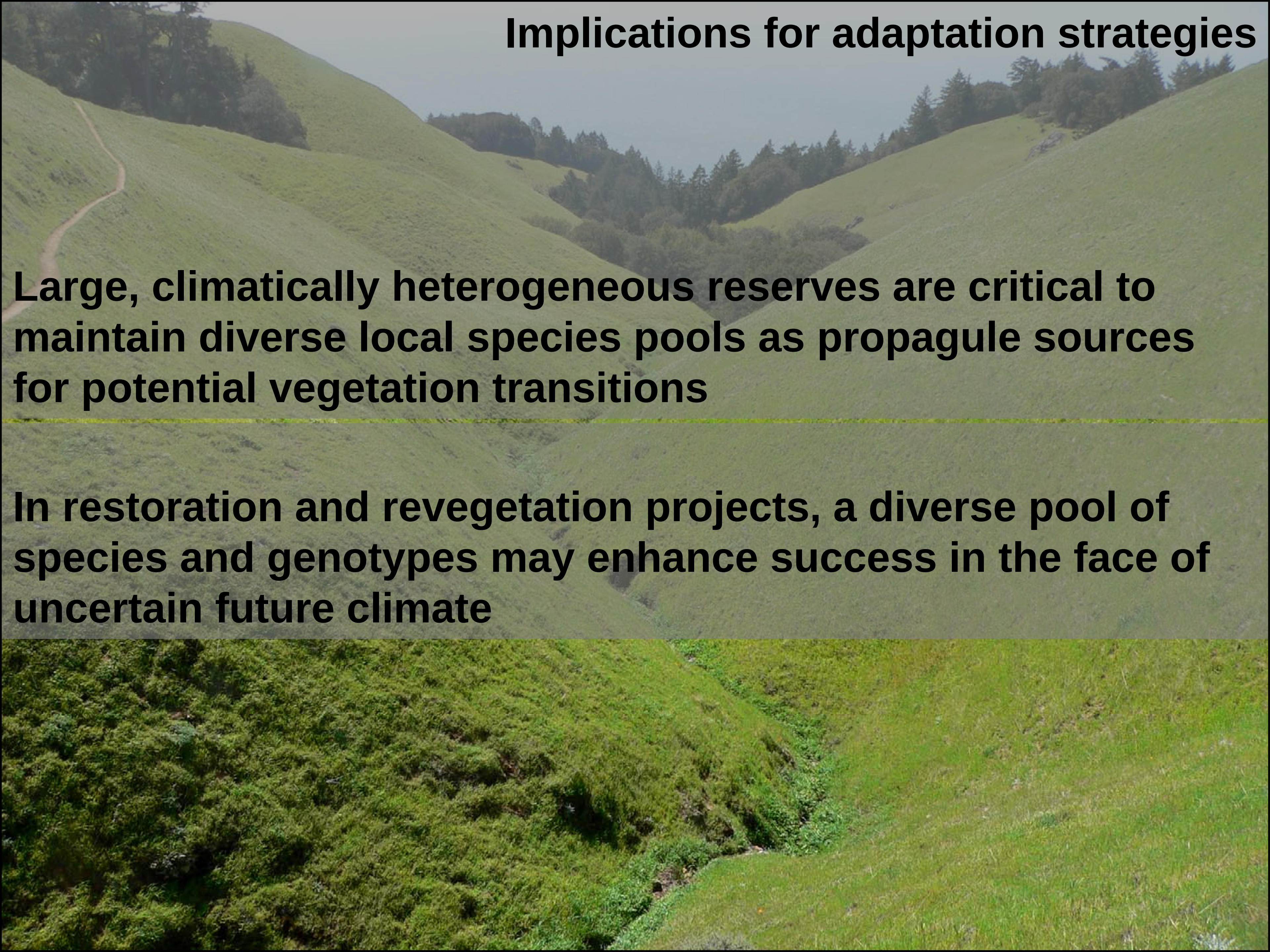
Eradication of invasives is more important than ever in the face of changing climates!

sources: nps.gov, cal-ipc.org

Implications for adaptation strategies

Large, climatically heterogeneous reserves are critical to maintain diverse local species pools as propagule sources for potential vegetation transitions

In restoration and revegetation projects, a diverse pool of species and genotypes may enhance success in the face of uncertain future climate

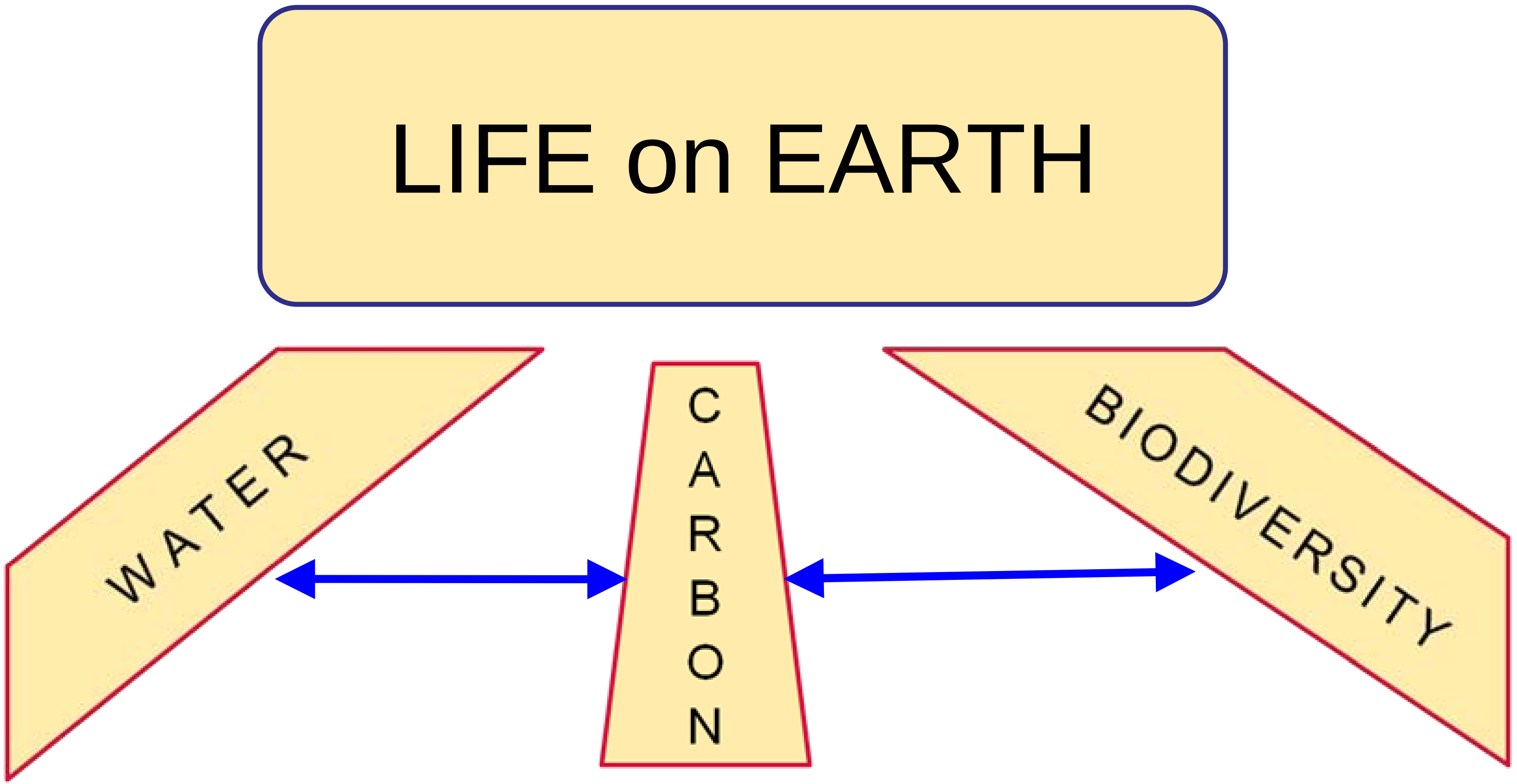


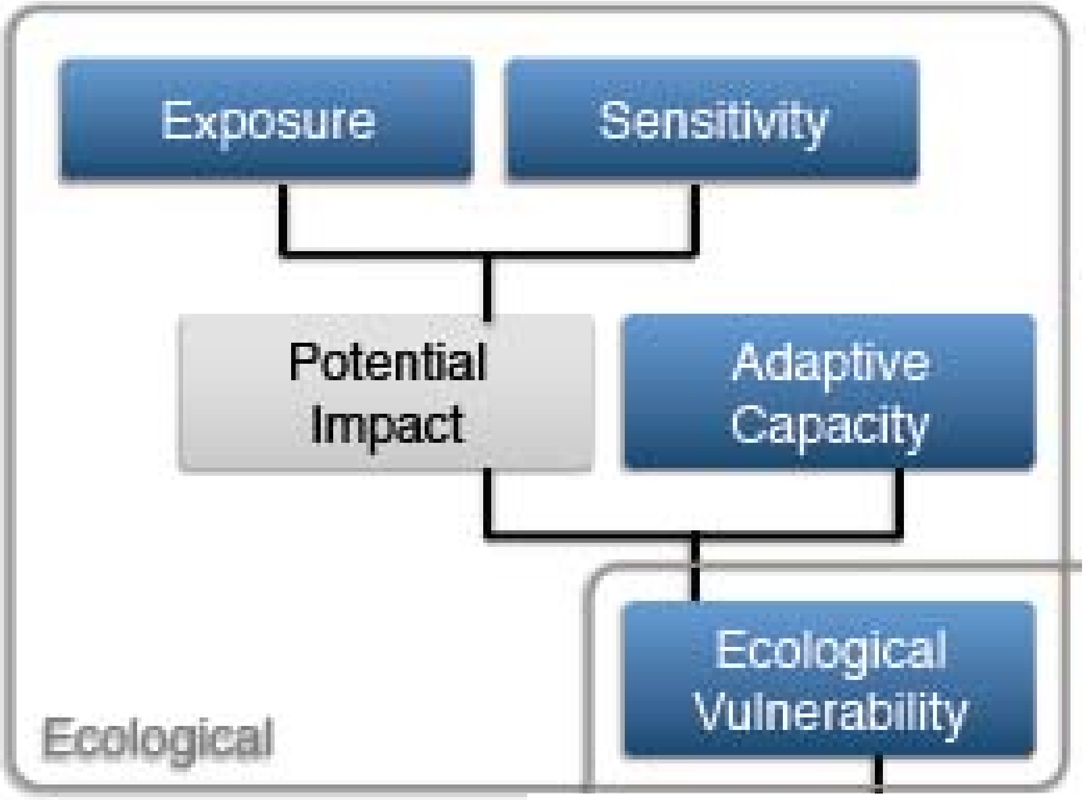
Species vs. reserve-based approaches

- Species and habitat based approaches
  - Where will species move in future?
  - What is the fate of individual species or community types in a changing climate?
  - What actions will enhance conservation of individual species?

- Reserve-based approaches focus on *place*
  - What will a reserve look like in 50 years? 100 years?
  - What species will live there?
  - What actions will promote healthy vegetation, recreation value, ecosystem services, etc., *even if they are not the same as those we have today?*

Must Manage for Multiple Benefits Simultaneously





After Marshall et al. 2010

Ecological Adaptation Strategies

- *More and larger protected areas and open space*
- *Connect protected areas*
- *Reduce other stressors*
    - *Invasive species*

Adaptation planning for slow directional shifts

slide courtesy Rebecca Shaw, TNC

Human System Adaptation Strategies

Direct ecological impacts

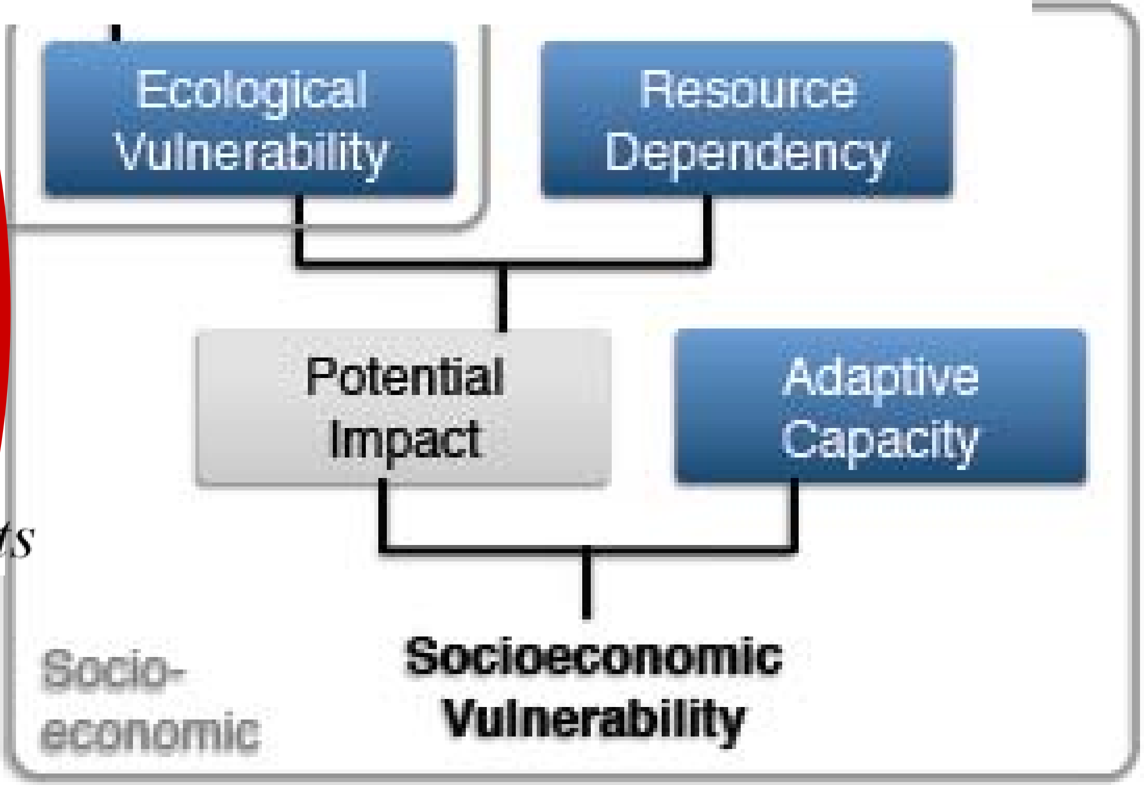
- *Sea walls*
- *Levees and pumps*
- *Dams*
- *Fortify existing and develop new infrastructure*
- *Retreat/resettle*
- *Fuel load reduction*

GHG emissions impacts

- *Desalinization*
- *Air conditioning*

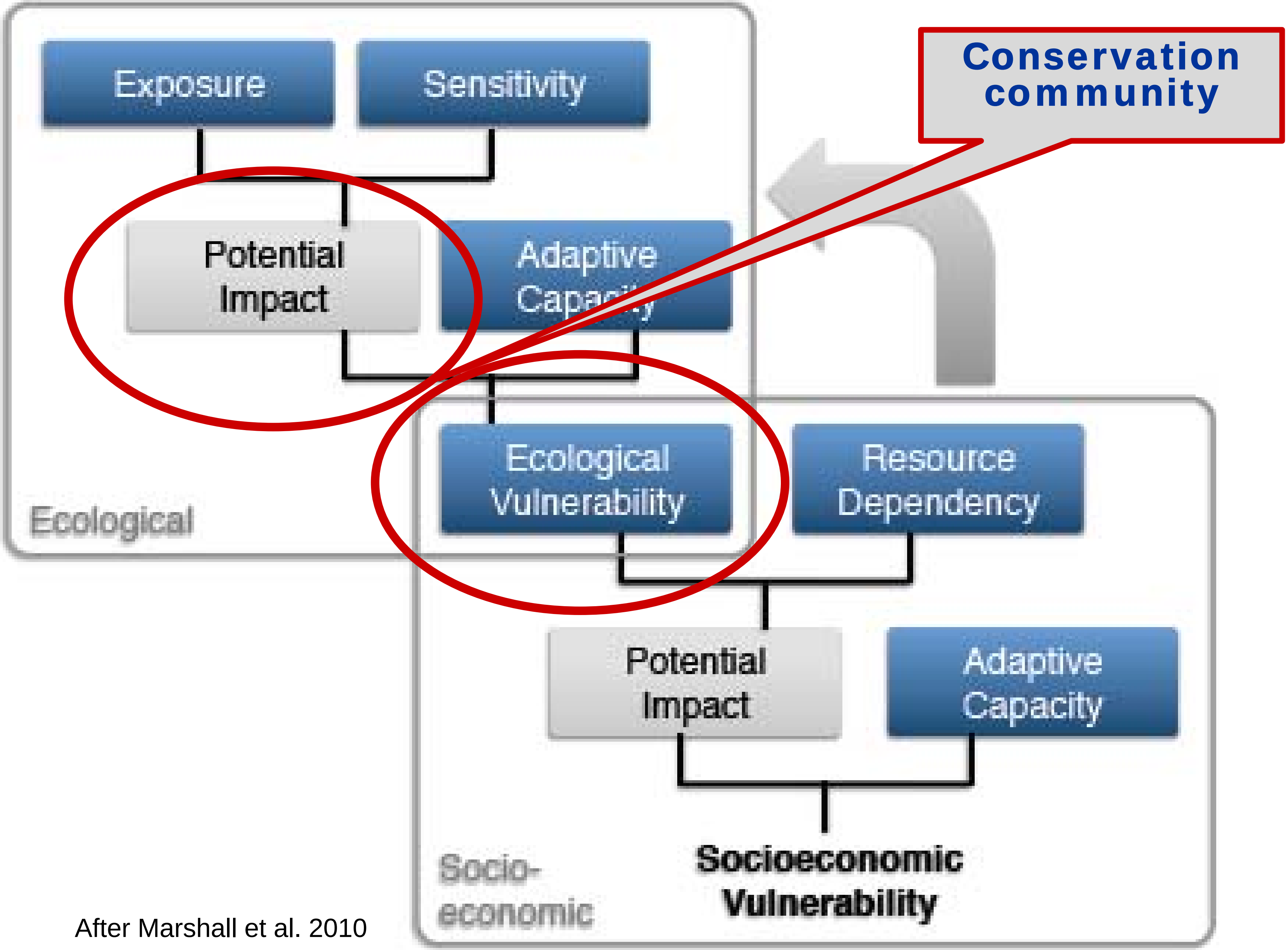
Collision Course:

Many of the human adaptation strategies undermine ecological adaptation strategies.



After Marshall et al. 2010

slide courtesy Rebecca Shaw, TNC



After Marshall et al. 2010

slide courtesy Rebecca Shaw, TNC

Ecosystem-based adaptation

"Ecosystem-based adaptation is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.

"Ecosystem-based adaptation uses the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change."

Report of the CBD's Ad Hoc Technical Expert Group on Biodiversity and Climate Change

Bay Area Ecosystems Climate Change Consortium

www.baeccc.org

Bringing together scientists, natural resource managers and planners to:

- Reduce negative impacts of accelerating climate change on the region's wildlife, habitats & ecosystems from the SF Bay uplands and estuary out to the Greater Gulf of the Farallones;
- Secure nature's benefits to society.

The time is now!